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# AUTOMOBILE FUEL EFFICIENCY STANDARDS

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# HEARING

BEFORE THE

## SUBCOMMITTEE ON ENERGY REGULATION AND CONSERVATION

OF THE

## COMMITTEE ON ENERGY AND NATURAL RESOURCES UNITED STATES SENATE

ONE HUNDRED FIRST CONGRESS

FIRST SESSION

ON

AUTOMOBILE FUEL EFFICIENCY STANDARDS

APRIL 4, 1989

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# AUTOMOBILE FUEL EFFICIENCY STANDARDS

TUESDAY, APRIL 4, 1989

U.S. Senate,
Committee on Energy and Natural Resources,
Subcommittee on Energy Regulation and Conservation,
*Washington, DC.*

The subcommittee met, pursuant to notice, at 9:32 a.m., in room SD-366, Dirksen Senate Office Building, Hon. Howard M. Metzenbaum presiding.

## OPENING STATEMENT OF HON. HOWARD M. METZENBAUM, U.S. SENATOR FROM OHIO

Senator Metzenbaum. This morning on Alaska's Prince William Sound, there are 10 million gallons of oil afloat on the water smothering wildlife in a mass of toxic slime the size of the State of Rhode Island, choking the economy of the State of Alaska, and shocking the entire Nation into a terrible awareness of the vulnerability of our environment and our energy policy.

What does that have to do with fuel economy standards for automobiles? Plenty. The Exxon spill presents a dramatic reminder of the costs and the risks of our current energy course. The disruption in supplies following the Alaska spill has given rise to higher consumer prices. We have seen oil prices jumping, oil companies gouging the American people, a 30 cent increase in West Coast gas prices, retail dealers in Ohio publicly protesting about the increased prices.

Every time this Nation has any kind of a development that makes it possible for the oil companies to gouge the American people, the oil companies move in promptly and do it. Who can ever forget when Americans were forced to wait in line for hours in order to buy gasoline while the prices soared to unbelievable heights and the oil companies kept their ships off shore so that they might await even further increases?

There isn't any logical reason for the oil companies to be exploiting this situation in Alaska in order to gouge the American people. It speaks poorly for the responsibility of the oil industry in this Nation. And exploitation of the oil industry's own irresponsibility winds up with their profiting from that irresponsibility. That is bad enough, but it's small potatoes compared to the kind of price rise we would see in a temporary cutoff of oil imports into this country.

So, behind the environmental tragedy that shakes us all, the spill reminds us of the dangers inherent in our increasing dependence on petroleum imports. Soon we will import half our oil supply, a level this country has never seen even during the energy crisis of the 1970s. OPEC has it where it wants us again. Before he left office, President Reagan called oil imports a threat to national security.

Those are some of the reasons today's topic relates directly to the Exxon spill. Most importantly, corporate average fuel economy standards can save twice the amount of oil just spilled in the Prince William Sound, and it can save that much every single day. Twice the amount of oil saved every day of every week of every year. Two oil spills' worth of savings every day.

We have witnesses today who will discuss the availability of gasoline saving technologies, such as the four-valve per cylinder engines. They offer impressive potential for tremendous energy savings, savings achieved without sacrificing jobs, without sacrificing consumer demands, and without sacrificing our environment. These technologies are as practical for large cars as small ones.

Senator Nickles, who prodded me to call this hearing, indicated to me that his family of six needed a larger car. It seems to me that he and others like him will stand the most to gain if we can get the auto makers to improve the gas economy of all models. This may all sound too good to be true, but it's not.

In the past decade, the interior space of new cars remained the same and their horsepower increased by about 20 percent. But average fuel economy has doubled. Look at the Pontiac Grand Am, no one's idea of an economy model. With GM's Quad-4 engine, it gets 32 miles per gallon; and the Chrysler LeBaron, 32 miles per gallon; and the upscaled Toyota Camry, 33 miles per gallon. The next time he is in the market for a family car, maybe Senator Nickles ought to test drive a Buick Century wagon, 31 miles per gallon. I won't even mention some of the smaller cars with much higher mileage.

But not every car today is being built with these engineering improvements. In fact, the Reagan Administration relaxed the CAFE standards for cars in each of the last four years. The message to auto companies was clear. The government believes efficiency doesn't matter anymore, and you can do whatever you want regardless of its impact on society.

And when I make that statement about the government, I'm talking about the Reagan Administration, and I am not addressing myself to the Bush Administration from whom we will hear today. It is time to put out a different message.

An analysis last year by DOE experts determined that the new car fleet could reach 35 miles per gallon by 1995 while remaining practical and cost effective without a shift in size mix, performance or luxury equipment. And by pursuing a strong CAFE that relies on technological improvements, we are also asking American workers to make no sacrifices.

The automakers have in the past complained that fuel economy standards would throw U.S. workers out of their jobs. When CAFE standards were rolled back by the Reagan Administration, we saw a rapid increase in the importation of small cars by the domestic industries and with it the exportation of small car jobs.

I know that we will hear these threats again, that if we tighten CAFE, they will stop the manufacture of their larger and more profitable models. I don't buy it. I am certain that the auto makers will not discontinue selling these profitable models just so they can avoid improving the average fuel efficiency of their fleet. A properly structured CAFE will improve the international competitiveness of domestic auto makers, and we simply can't allow an erosion in the fuel economy of the efficient manufacturers.

Before we begin, I would note that we invited both the Office of Technology Assessment and Chrysler to testify, but both declined to do so. I am especially concerned about OTA's absence. OTA has the expertise and, indeed, has been working in the area of auto fuel economy. However, their work was a component of a wide-ranging assessment of future U.S. energy supply and demand that the House Energy and Commerce Committee requested in 1985. That assessment is not complete, and Representative Dingell has asked OTA not to testify at this time before this subcommittee. I understand that, and I look forward to receiving that information when it is complete.

[The prepared statements of Senators Metzenbaum, McClure, Nickles and Gore follow:]

# STATEMENT OF SEN. HOWARD M. METZENBAUM
CHAIRMAN
SUBCOMMITTEE ON ENERGY REGULATION AND CONSERVATION
HEARING ON FUEL EFFICIENCY STANDARDS
APRIL 4, 1989

This morning, on Alaska's Prince William Sound, there are ten million gallons of oil afloat on the water--smothering wildlife in a mass of toxic slime the size of the state of Rhode Island, choking the economy of the state of Alaska, and shocking the entire nation into a terrible awareness of the vulnerability of our environment, and our energy policy.

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**OPENING STATEMENT**
**SENATOR JAMES A. McCLURE**
**COMMITTEE ON ENERGY AND NATURAL RESOURCES**
**TUESDAY, APRIL 4, 1989 (9:30 A.M.)**

## AUTOMOBILE FUEL ECONOMY STANDARDS

Good morning. I agree that current levels of petroleum imports present a threat to our national security. I also agree that transportation consumes by far the majority of our petroleum supplies -- in fact, 63 percent of our nation's petroleum supplies. Any national energy policy therefore must address the transportation uses of energy.

However, the record should indicate that the matter of automobile fuel economy standards does not lie within the jurisdiction of the Energy and Natural Resources Committee; it is within the jurisdiction of the Commerce Committee. Therefore this hearing must, of necessity, be an oversight, not legislative, hearing.

The subject of automobile fuel economy standards is under review by the Bush Administration in two forums. First, the Secretary of Transportation is currently acting on a petition to relax the current CAFE standard for Model Year 1990 automobiles. His decision is expected in a matter of days. It is unfortunate that we could not have scheduled these hearings after he had rendered his decision on the proposed Model Year 1990 standard.

In addition, the new Administration has undertaken a review of policy options for stabilizing global climate change. Their review will include an evaluation of energy technologies to improve automobile fuel economy. This is a priority matter with the Bush Administration, and we can expect an early indication of the Administration's recommendations on this matter.

This Committee also is conducting full Committee hearings on the energy policy implications of global climate change; in fact, there currently is an amendment to S. 324 pending before the full Committee regarding CAFE standards.

The point that needs to be made here is that the matter of global climate change, including automobile fuel economy standards, is receiving priority attention, as it should, from both the Administration and the Congress. What is needed is an integrated approach that can be supported by all parties.

As a part of this ongoing review I look forward to today's testimony.

## STATEMENT OF
## SENATOR DON NICKLES, RANKING REPUBLICAN
## SUBCOMMITTEE ON ENERGY REGULATION AND CONSERVATION

## HEARING ON AUTOMOBILE FUEL EFFICIENCY STANDARDS
APRIL 4, 1989

Mr. Chairman, I appreciate the fact that you are holding a hearing on automobile fuel efficiency standards and on your proposal to increase Corporate Average Fuel Economy requirements to 34 miles per gallon by the year 2000. This subcommittee has not held a hearing on CAFE since May of 1985. Not only have our respective roles changed since 1985, when I chaired the Subcommittee, but Congress has undertaken a serious review of its efforts to regulate the energy marketplace.

Since 1985, the Congress has generally eliminated all the energy regulatory machinery established during the panic over increasing oil costs during the mid-1970's. Of course, oil was decontrolled in 1981. Since our last hearing, Congress has repealed most of the Fuel Use Act, the Natural Gas Act's Incremental Pricing Provisions, the Windfall Profits Tax, and the Synthetic Fuels Corporation. Pursuant to the NGPA, most of this country's natural gas is now decontrolled, with positive results for consumers rather than the dire "fly-ups" predicted by Consumer/Labor Energy Coalition and other regulatory advocacy groups. I hope the Chairman will cosponsor Senator Ford's and my bill, S. 625, to eliminate the remaining wellhead controls on natural gas.

Congress generally has been willing to revisit its counter-productive energy overregulation, and correct its past mistakes. Although CAFE has not yet been repealed, it is undergoing a thorough review in the Bush Administration and at the Office of Technical Assessment. I hope those reviews will encompass the Chairman's proposal to extend and expand CAFE. It is my view that such a proposal would not be an overall benefit to the Nation and the American consumer, but rather, a detriment.

The CAFE standards have become increasingly costly in terms of the potential for losing US jobs or exporting them overseas, increasing trade deficits for automobiles, and increasing consumer costs while diminishing consumer choice. The Japanese automakers have been able to capitalize on their comparative price advantage in smaller, fuel-efficient cars to "subsidize" their high performance mid-sized car models. Meanwhile, US full-line car manufacturers are unable to increase their domestically produced small car sales in the face of foreign competition, and thus are being forced by CAFE standards to limit production of their popular, larger cars. The Federal Trade Commission, in its comments to the National Highway Traffic Safety Administration last September, estimated that between 15,00 and 20,000 jobs would be jeopardized by not lowering the 1990 CAFE standard to 26.5 mpg from the goal of 27.5. Obviously, the impacts on employment and the economy could be much higher if the standards are actually increased above 27.5, as in the Chairman's proposal.

In addition, consumers will lose both by having less choice in automobiles and in seeing higher prices for the larger cars they may need if they have a large family. The FTC estimates that the additional cost to consumers in the 1990 model year of not lowering the CAFE standard below 27.5 mpg would be almost $1 billion. The standards required under the Chairman's proposal would appear to be much costlier. The rich could still buy larger cars, but the not-so-rich will be essentially told by Congress that they can only drive smaller, or lower-performance cars.

The Department of Commerce summarized CAFE's deficiencies in its comments to NHTSA last September, stating that the "changes in product mix and reduced product offerings [forced by CAFE on Ford and GM] would have economically damaging consequences for U.S. automobile production and employment, and for consumers, that would exceed the modest benefits resulting from retaining a 27.5 mpg versus 26.5 mpg level."

Not only would the advantages of CAFE be at best modest, they could well be counterproductive. In its September comments, the Federal Trade Commission estimated last fall that a failure to lower the 1990 CAFE standard would actually increase gasoline consumption by 200 million gallons between 1990 and 2005.

To try to force mileage standards higher than 27.5 would further erode choice among affordable larger cars and generally increase car prices, forcing the non-affluent to keep their older cars longer. These older cars generally have much lower gas mileage and more polluting air emissions, defeating the Congressional desire to reduce oil imports and improve air quality.

Finally, attempts to mitigate these impacts by crafting provisions, such as the "anti-backsliding" provision in the Chairman's CAFE amendment, designed to prevent the Japanese companies from exploiting their competitive advantage under higher CAFE standards will probably only create new inequities in the program, not eliminate existing ones. We cannot ignore the fact that the Japanese automakers have a large base of small cars to use in complying with CAFE standards, at whatever level they may be set.

Generally, there is merit in energy conservation, so long as the costs do not outweigh the benefits. However, CAFE and attempts to expand CAFE are not only costly programs, they promise little or no positive benefits with respect to fuel consumption. As with many of the energy regulatory programs from the mid-1970's, CAFE is government meddling in the marketplace, reducing economic efficiency and increasing consumer costs while having little or no positive effect.

Mr. Chairman, in our headlong rush to "do something" about the spector of "global warming" or the concern about excess urban ozone, let us not make American car buyers and American autoworkers pay costs far in excess of any national gain in fuel efficiency. CAFE is not a cost-effective policy worthy of extension.

Albert Gore Jr.

Statement of

**SENATOR AL GORE**

Hearings on Automobile Fuel Efficiency Standards
Subcommittee on Energy Regulation and Conservation
Committee on Energy and Natural Resources
April 4, 1989

Mr. Chairman, eleven days ago, the worst oil spill in our nation's history polluted the pristine waters of Prince William Sound. Today, we are left once again with apologies for an environmental disaster that did not have to happen.

Many of us have heeded the call to be better stewards of the atmosphere, the water, and the land. We have learned that the environment is not just an infinite void into which we can discharge our pollution. If we continue to do so, we threaten the delicate balance that is the planet's ability to support life.

The oil now killing the wildlife and fish of Prince William Sound, and destroying the livelihood of the surrounding communities, was probably destined for our vehicles. Once burned, its emissions would have been dumped into our environment in another form, polluting the air in our cities and contributing to changing the climate of our planet.

We have heard calls for global cooperation to protect the world's environment. But that protection must begin here at home. Our cars and trucks are responsible for much of the air pollution choking our cities, and a large portion of the carbon dioxide emissions of our nation.

Thus, one of the first steps to demonstrate U.S. leadership in protecting the global environment must be to increase the efficiency of our transportation sector, in which each American consumes more energy than a person in almost any other country consumes in all economic sectors combined. We do not need to speed development of environmentally sensitive areas to produce more oil for our vehicles; we can "produce" that oil in an environmentally and economically sound way, through increased vehicle fuel efficiency.

After dramatic improvements in the 1970s, and general stability in the 1980s, average new vehicle efficiency in 1988 was actually lower than the standards set originally for 1985. The average new vehicle produced in the U.S. got 27 miles per gallon in 1988; the average Asian import got 32 miles per gallon.

The trend away from improved vehicle fuel efficiency has been hastened by another trend during the 1980s, back toward higher horsepower; in effect, the fuel efficiency wars of the 1970s have been replaced by the horsepower wars of this decade.

Clearly, improvements in vehicle fuel efficiency are long overdue, and they make sense for a variety of reasons:

- Oil imports cost our trade balance $40 billion in 1988; for every one mile-per-gallon increase in car and light truck fleet efficiency, we could reduce oil imports by 320,000 barrels per day -- even at only $12 per barrel, that's $1.5 billion off our trade deficit each year.

- Our national security is threatened by an over-reliance on those oil imports to fuel the majority of the entire U.S. transportation sector.

- Our competitiveness in international markets is compromised by energy-inefficient products in a world where continued depletion of finite oil resources can only lead to increased fuel costs.

- Our vehicle fleet contributes as much as one-third of U.S. carbon dioxide emissions (overall, our nation emits more carbon dioxide than any other nation in the world).

- Last but not least, urban air quality in many cities is not coming into compliance with standards deemed necessary to avoid adverse impacts on human health. Among the major pollutants addressed by the Clean Air Act, the two that have proven most difficult to control -- carbon monoxide and ozone -- are largely due to our automobiles. Over 100 urban areas are not meeting air quality standards for one or both of these pollutants.

Our addiction to the Middle East's oil is again on the rise. Our trade balance is again on the decline. Our national security is at stake, and the environment demands our stewardship.

Burning less fuel in our vehicles is one sure way to address all of these demands. On the first day of the 101st Congress, I introduced the World Environment Policy Act of 1989. My legislation is designed to address many of the sources of the global environmental crisis, including a call for new vehicle efficiency standards. It is my understanding that the Commerce Committee will hold hearings on vehicle fuel efficiency standards soon. I share and applaud this Subcommittee's interest in this issue, and hope that we can work together as the Commerce Committee explores it further at the earliest possible date.

And as we address this issue, we must realize that burning less fuel in our vehicles means not only driving more efficient vehicles; it also means stemming growth in the number of miles we drive. The Federal Highway Administration projects that in urban areas, the total number of miles traveled by vehicles will increase 50% to 80% by the year 2010. New vehicle fuel efficency standards, which my legislation proposes, are the first component of reducing the fuel consumed by our vehicles. But a re-thinking of urban and suburban transportation must be the second component.

Just as new commitments to clean up the environment were being sounded around the world, just as new international initiatives were being forged to protect our planet, eleven million gallons of crude oil pierced an ecological treasure. The disaster in Prince William Sound must be a turning point. If we are to leave our children a legacy of care and stewardship, we must take responsibility for the entire planet. Each of us must find within ourselves the foresight and the courage to confront this serious global challenge.

Senator **Metzenbaum**. I am very pleased that Senator Wirth is with us here this morning.

Senator Wirth?

## STATEMENT OF HON. TIMOTHY E. WIRTH, U.S. SENATOR FROM COLORADO

Senator **Wirth**. Thank you very much, Mr. Chairman, and I'd like to include an opening statement in full in the record if I might.

Senator **Metzenbaum**. Without objection, so ordered.

Senator **Wirth**. I thank our witnesses for being here.

Mr. Chairman, the American public is absolutely astonished and horrified by what has happened in the last 10 days in Alaska. And your timing of your hearing could not be better. What is the relationship between the two?

The spill in Alaska was approximately 200,000 barrels of oil. If we were to raise automobile fuel efficiency standards to 34 miles per gallon, we would save approximately 400,000 barrels per day. In other words, what we are about to hear today is a hearing on the possibility of saving two disasters per day, two Valdez spills per day.

For those who say that we cannot move on automobile fuel efficiency standards, I say we've been through this before. I remember in 1975 when we were at the height of the Arab embargo, the auto industry and related groups came in and said that there was no way in the world that they could reach automobile efficiency standards. They came in and told us that there was no way that the Federal Government ought to be involved in their business. It reminded me of what Henry Ford said years ago. The country discovered safety glass. Henry Ford came in and said we're in the business of selling automobiles, not safety.

It seems to me that the time has come for this industry, enormously powerful with a lot of very good friends on Capitol Hill, with an enormous amount of clout in the country and a great deal of responsibility at the same time to the American people, to once again involve itself as a responsible citizen, as a responsible citizen to say that the time has come to move forward in terms of making automobiles more fuel efficient.

It is absolutely preposterous that we in the United States, facing not only the immediate crisis of a Valdez, but the long-term crisis of global warming, of acid rain, of all the related environmental issues with which the American public and publics around the world are increasingly concerned—it is preposterous that we're in a situation of declining fuel economy standards and not increased fuel economy standards.

I can't believe that the automobile industry doesn't understand that the greatest single area in which we in the United States can make progress is the area of energy conservation. And yet, that doesn't happen. We are told that somehow the United States can't compete with the world. I mean, that's an extraordinary admission of incompetence or inefficiency or lack of will. Maybe it's all of them, Mr. Chairman. I would hope not.

It's my hope that we can move ahead aggressively in terms of the kind of fuel efficiency economy standards that you're advocating, Mr. Chairman, that many of us have fought for for year after year after year.

In closing, Mr. Chairman, I would once again harken back to the mid-1970s when we had a crisis in the United States. The industry came in and told us—I was a member of the Commerce Committee on the House side at the time. Mr. Dingell was the chairman of the energy subcommittee on the House side. And the automobile industry came in and told Mr. Dingell and that committee that there was no way that we ought to be enforcing fuel efficiency standards.

Well, the Congress did so in 1975 and 1976. The Congress did so, and it was probably the only item that saved the automobile industry at a time of enormous crisis. It happened, and it happened that it caused no problems whatsoever. I would hope that we might be able to once again not only forge the political will on the committee, Mr. Chairman, but also enlist the help of the automobile industry, an enormously important part of our economy, the fabric of this society, and once again hope that they could join us in looking at the future rather than just the immediacy of the bottom line.

Thank you very much, Mr. Chairman.

[The prepared statement of Senator Wirth follows:]

Timothy E. Wirth

## STATEMENT OF THE HONORABLE TIMOTHY E. WIRTH

April 4, 1989

Mr. Chairman, I would like to thank you for your leadership on this critical issue. Looking back over my years in public service, I can think of only a few issues that have been as controversial and as vexing as CAFE. It is an extremely complex and emotional issue for all of us in the public policy community.

Today, we are addressing this issue in the face of some enormous challenges in the areas of energy and the environment.

In the energy arena, the climate has changed in three short years from a period of relative security to one of great uncertainty. Imports are up dramatically, from 28 percent of domestic consumption in 1985 to more than 40 percent of consumption in 1988. The transportation sector continues to be captive to petroleum. About 65 percent of the petroleum used in this country is consumed in the transportation sector -- and that situation is unlikely to change in the near future.

Our concerns about the health of the environment in the United States and around the world are also growing. Ozone levels throughout the United States rose to new heights during the blistering summer of 1988. Acid rain is falling in the Eastern United States and is a grave threat to my state and others in the great West. And to my mind, most troubling of all, evidence is building on a daily basis that our thirst for fossil fuels and our push to clear the forests of this planet is a grave threat to the forces which govern Earth's very fragile thermostat. Carbon dioxide levels are rapidly increasing in concentration in the atmosphere. Here again, the transportation sector plays a significant role. Each gallon of gasoline we burn produces about 20 pounds of carbon dioxide. In fact, cars account for 25 percent of U.S. CO2 emissions.

The concerns of energy security and environmental integrity are converging, and nowhere do they meet more clearly than on the issue of automobile fuel efficiency. The trends in this regard are very troubling. At a time when we want to reduce our dependence on imported oil and reduce emissions of carbon dioxide, carbon monoxide and other pollutants, the fuel efficiency of the cars driven in this country is worsening. According to data compiled by the Department of Transportation, the overall fleet average for new passenger autos and light trucks slipped by 2/10s of a mile per gallon in 1987. It slipped by about 3/10s of a mile per gallon in 1988. We are, quite literally, driving in the wrong direction.

It is pointless for us to try to find villians to blame in this trend. We cannot solely lay blame on the doorstep of the automobile giants. We cannot, as some have suggested, solely lay the blame on a public that is said to be crazed by 200 horsepower engines and gas-guzzling cars. Regardless of the causes, I do not believe that we can continue to sit back complacently and accept these trends. We simply must work together to ensure that our autos, like our economy, and like our nation, become more efficient, healthier and cleaner.

I believe that the decisions by the previous administration to roll-back the CAFE standards during the past four years are among the most bankrupt public policy decisions in recent history. They show no appreciation for the long-term considerations of energy security, environmental health, and our balance of trade. No one in this country wants to repeat the experiences of a decade ago, when we had to wait in line to buy our gas. No one wants to see our climate or the environment deteriorate. And no one wants to see our efforts to improve international competitiveness weakened by a large trade deficit -- much of it going to buy foreign oil. So we have to work together to clean up our act; to move forward, not backwards.

We know that the technology to improve the efficiency of our auto fleet is available. Recent public opinion polls suggest that while it is a submerged concern, the public supports energy efficiency and efforts to protect the environment. What we need now is a commitment among all parties to harness these capabilities. The automobile industry is to be commended for responding to the original legislation that established CAFE standards. As a nation, we have doubled the efficiency of new cars in just over a decade. Why cannot we repeat that success? Are we unable to overcome the hurdles? Can we afford not to become more efficient? I think the answers are clear.

I think we should work together to implement a four-step strategy to improve energy efficiency in the transportation sector. First, we should raise our sights and set new CAFE standards through the year 2000. Second, we should develop incentives to stimulate demand for fuel-efficient cars. An increased gas-guzzler tax could be employed, for example, to finance rebates for buyers of the most fuel-efficient cars. Third, federal and state governments should take the lead by steadily increasing the efficiency of their automobile fleets. And finally, the public and private sectors should work together to let the public know the energy efficiency is a necessity -- even now when oil prices are low. I think every American should be encouraged to make sure that their next car is more efficient than the last.

If we fail in these efforts, environmental systems will inch closer to the edge of collapse; our economy will be rocked when the next energy crisis hits -- and it will come as sure as we are all sitting here. And, for the industry representatives here with us today, I would like to suggest that when that next energy crisis comes, when we realize once again how narrow the Straits of Hormuz really are, the automobile industry in this country may be unprepared because it appears that domestic auto producers have handed the market for fuel efficient vehicles over to our foreign competitors.

Let me conclude, Mr. Chairman, by saying that the demand for fuel efficiency in automobiles is building. That was evident three weeks ago in in this room, when this Committee cast a tie vote on Senator Metzenbaum's modest and commendable amendment to the ANWR legislation.

Finally, I have this thought. According to work done by the staff of this Committee, the difference between the current leveling off in fuel economy and a modest efficiency increase to 34 miles per gallon by the year 2000, is about 400,000 barrrels of oil per day at the turn of the century. That's what we face, Mr. Chairman -- 400,000 barrels of oil per day. Twice as much crude oil as spilled out of the hull of the Exxon Valdez to sully the waters, wildlife and wonder up north in Alaska. We must do much better. Thank you very much.

Senator **Metzenbaum**. Thank you, Senator Wirth. Senator Wirth, you have certainly given great leadership in the House and continuing on here in the Senate in this area as well as so many others. And I'm grateful to have you participating with us.

I am very pleased that Senator Rockefeller is with us this morning. Senator Rockefeller, do you have an opening statement?

Senator **Rockefeller**. Thank you, Mr. Chairman. I'm not on this subcommittee, but this is a matter of enormous importance. And I spent a good day out in Detroit last week discussing this whole matter with the automobile companies. So, I'm interested to hear what is said, and I look forward to the testimony.

Senator **Metzenbaum**. I'm very happy to have you sit with us, Senator Rockefeller.

Senator Murkowski, do you have an opening statement?

## STATEMENT OF HON. FRANK H. MURKOWSKI, U.S. SENATOR FROM ALASKA

Senator **Murkowski**. Mr. Chairman, I'd just like to take this opportunity to note that when we enacted CAFE standards, we also coincidentally opened up Prudhoe Bay, and both came into market about the same time. I think their contribution to our energy mix realistically was about the same, about 2 million barrels saved from the CAFE standards, and about 2 million barrels coming from Prudhoe Bay.

My point is one cannot look at our current situation and say we should only have adopted CAFE standards. I think you would agree, Mr. Chairman, that energy policy is a mix, a mix of conservation and production, not just one.

Thank you, Mr. Chairman.

Senator **Metzenbaum**. Thank you. I'm very happy to have you with us this morning, Senator Murkowski.

The staff has prepared some charts that will be put up at various points during the hearing. They are committee staff preparations.

We're happy to have with us this morning the Honorable John R. Berg, Assistant Secretary of Conservation and Renewable Energy for the U.S. Department of Energy; Mr. Richard Morganstern, Director of the Office of Policy Analysis for the Environmental Protection Agency; and Mr. Howard Smolkin, Managing Director of the National Highway Traffic Safety Administration of the Department of Transportation.

Mr. Berg, we will be very happy to hear from you first. The committee normally adopts a five-minute rule for testimony. I hope somebody has advised you to that effect.

## STATEMENT OF DR. JOHN R. BERG, ASSISTANT SECRETARY FOR CONSERVATION AND RENEWABLE ENERGY, DEPARTMENT OF ENERGY, ACCOMPANIED BY DR. CARMEN DIFIGLIO, DEPUTY DIRECTOR, OFFICE OF POLICY INTEGRATION

Dr. **Berg**. Thank you very much. We are pleased to be here and do apologize for the traffic delay in getting us over here this morning.

I have a statement which I have submitted for the record. If I may, I would like to summarize it orally.

Senator **Metzenbaum**. Without objection.

Dr. **Berg**. Thank you very much, sir.

I am accompanied today by Dr. Carmen Difiglio, the Deputy Director of the Office of Policy Integration, on my right here.

I appreciate this opportunity to appear before you today to provide information on the potential to improve automobile fuel efficiency. Our Nation's increasing dependence on imported petroleum is a serious problem that must be addressed by a balanced, integrated energy strategy.

Efficiency improvements are an important element of a balanced energy policy. Such a policy must also address the needs to increase domestic production, diversify energy supplies and to encourage alternative fuel use. Secretary Watkins is committed to the development of a national energy strategy that addresses energy security concerns in a way that also enhances our economic efficiency and safeguards the environment.

Between now and the model year of 1995, additional automobile fuel economy is technologically feasible. The fuel efficiency of cars can be improved by increasing the use of existing technologies. These technologies include front-wheel drive, overhead camshafts, roller cams, multi-point fuel injection, four-valve four and six cylinder engines, electronic transmission control, aerodynamics, reduced accessory drag and improved lubricants and tires. But many of these technologies provide increased performance, in addition to or instead of increased fuel efficiency. The ultimate fuel economy will depend upon the consumers' buying preference.

Beyond 1995 the research sponsored by the Federal Government and the private companies will continue to bear fruit in better materials, and will improve components and system designs which will increase energy use efficiency and make alternative fuel use both reliable and economically attractive.

For example, in the Department's transportation program, the first phase of design and procurement of improved ceramic components for the automotive gas turbine have been completed through the collaborative efforts with the ceramic industry. These components, when developed, will enable operation of small gas turbine engines at temperatures in excess of 2,500 degrees Fahrenheit thereby providing potential energy improvements of more than 30 percent over today's technology.

Higher transportation fuel efficiency can be a part of a national strategy to mitigate rising oil import dependence. We recognize that there will be differences of view on how to achieve this improved fuel efficiency and the appropriate governmental role in this regard. The Department of Transportation has the legal authority to establish corporate average fuel economy standards. The Department of Energy's role is to provide information and advice on the technological feasibility of higher CAFE standards and on the Nation's energy conservation needs.

The Department of Energy is required, by law, to provide comments to the Department of Transportation in the event that the proposed standards would adversely affect the conservation goals set by the Secretary of Energy. The Department of Transportation considers DOE's comments, along with several other important factors, in the broader context of establishing standards that meet congressionally mandated criteria.

In summary, the administration is in the process of reviewing oil conservation policy options as part of its preparatory work for development of a national energy strategy. We intend to also examine options under the existing authority to assess what, if any, legislative changes would be desirable.

In addition, the role of improved fuel efficiency must be placed in the context of a broader energy strategy that combines a balanced mixture of energy efficiency improvements, increased domestic energy supply and the substitution of more reliable and diverse energy sources. The Secretary of Energy is committed to the development of this integrated national energy strategy and has called for the increased national attention to conservation.

Mr. Chairman, we appreciate the opportunity to appear before you today and to gain your advice on these matters. I'd be happy to answer any questions which you or the subcommittee may have. Thank you.

[The prepared statement of Dr. Berg follows:]

# STATEMENT

OF

DR. JOHN R. BERG
ASSISTANT SECRETARY
FOR
CONSERVATION & RENEWABLE ENERGY
DEPARTMENT OF ENERGY

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES

SUBCOMMITTEE ON ENERGY REGULATION AND CONSERVATION

UNITED STATES SENATE

APRIL 4, 1989

I am happy to have the opportunity to appear before this Subcommittee today to discuss our potential to improve automobile fuel efficiency.

## Introduction

Our Nation's increasing dependence on imported petroleum is a serious problem that must be addressed by a balanced, integrated energy policy. Oil consumption is increasing, domestic production is in decline and, as a result, dependence on foreign supplies is rising. The transportation sector's near total dependence on large volumes of petroleum plays a key role in oil demand and supply policy. Over the past 15 years, automobile and light truck efficiency improvements have made a substantial contribution to reducing demand for oil. The Department of Energy has studied and continues to investigate the potential for further cost-effective efficiency improvements. This research has been conducted since the Department's inception.

Efficiency improvements are an important element of any balanced energy policy. Such a policy must also address the need to increase domestic production, diversify energy supplies, and encourage alternative fuel use. Secretary Watkins is committed to the development of a national energy strategy that addresses energy security concerns in a way that also enhances our economic efficiency and safeguards the environment.

## Background

In 1973, the average new car sold in the United States traveled only 14 miles on a gallon of gasoline. By 1987 the average new car sold in the U.S. achieved a fuel efficiency above 28 MPG. This extraordinary accomplishment of American industry placed U.S. automobiles on a par with those being purchased in Europe and Japan, where fuel prices are two to three times what American motorists pay.

Clearly, we have accomplished a great deal since the energy sector disruptions of the 1970s. While the trend in fuel economy for cars actually purchased has been consistently upward, and has significantly exceeded CAFE standards despite historically low gasoline prices, data for 1987 and 1988, and preliminary estimates for first 3-month 1989 sales, indicate a leveling of fuel economy progress.*

* See attached figure

## DOE's Role in DOT Rulemakings on Fuel Economy

The Department of Transportation has the legal authority to establish corporate average fuel economy (CAFE) standards. In carrying out his responsibilities in setting CAFE standards, the Secretary of Transportation is required by statute to consult with the Department of Energy. In this regard, the Department of Energy provides information and advice on the technological feasibility of higher CAFE standards and on the Nation's energy conservation needs. It should be noted that the Secretary of Transportation must also consider other factors in making his determination of maximum feasible average fuel economy. These other factors are economic practicability and the effect of other Federal motor vehicle standards on fuel economy. While the Department of Energy is concerned about these other important factors, the Department of Transportation has the responsibility to make those determinations.

Finally, the Department of Energy is required by law to provide comments to the Department of Transportation in the event that the proposed standards would adversely affect the conservation goals set by the Secretary of Energy.

## Review of Available Technologies

Between now and model year 1995, additional automobile fuel economy is technologically feasible. The fuel efficiency of cars can be improved by increasing the use of existing technologies. These technologies include front-wheel drive, overhead camshafts, roller cams, multi-point fuel injection, 4-valve four and six cylinder engines, electronic transmission control, aerodynamics, reduced accessory drag and improved lubricants and tires. All of these technologies are commercialized and are in use in vehicles sold in the U.S.

## Energy Conservation

Growing consumption of petroleum and declining domestic production have recreated an increasing U.S. dependence on imported oil. Oil use increased by half a million barrels per day last year and continues to grow. Domestic production has declined from a 1985 high of 9 MBD to 8.1 MBD in 1988. The combined effects of increased consumption and declining production raised oil imports for 1988 to 7.2 MBD. Imports from OPEC countries have supplied a large fraction of that increase. From a low of 1.8 MBD in 1985, imports from OPEC countries grew to 3.4 MBD last year. We are on a course that will lead in the early 1990s to historically high levels of oil consumption and imports reaching 50% of national requirements.

Increased oil demand in the United States and around the world, combined with growing cooperation among oil producers, has produced a rebound in oil prices. Near the end of 1987 crude oil prices were near $10 per barrel. Last week, May futures prices rose to $20 per barrel. However, predicting future oil prices is a tricky business, as we all know from past experience.

The transportation sector plays a crucial role in U.S. petroleum dependence. Oil use by the transportation sector in 1988 exceeded 10 MBD, up more than 2 percent from 1987, and almost 20 percent higher than in 1973. Transportation oil use alone exceeded U.S. production of petroleum in 1988 by 750,000 barrels per day.

## Conclusion

Past achievements in increased domestic energy production, in fuel substitution, and in greater energy efficiency have brought us the benefits of lower prices and abundant oil supplies. But shrinking domestic production, expanding demand, and growing import dependency require renewed attention.

The transportation sector, because of its reliance on petroleum-based fuels and because of the size of its oil consumption, is a key element in addressing the energy security problem. Higher transportation fuel efficiency can be a part of a National strategy to mitigate rising oil import dependence.

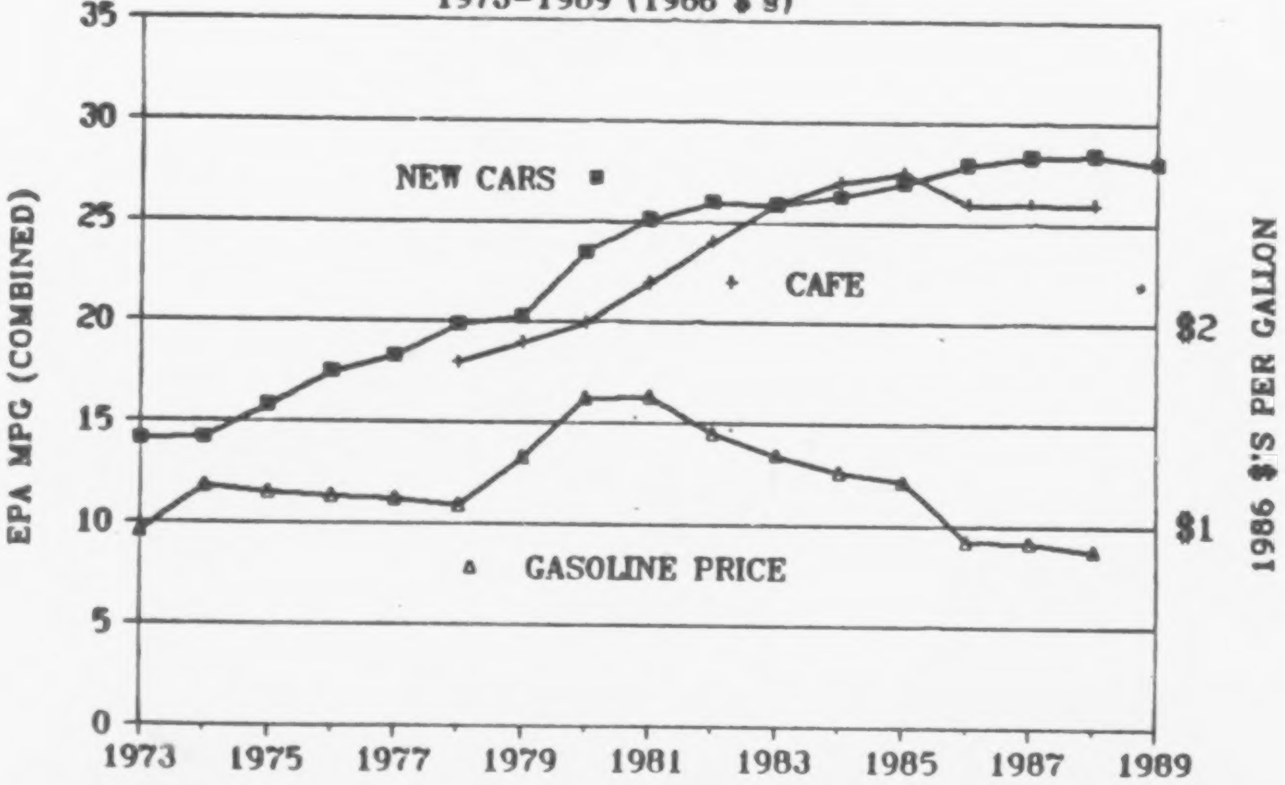
We recognize that there will be differences of view on how to achieve this improved fuel efficiency and the appropriate Government role in this regard.

Moreover, the Secretary of Transportation must consider several important factors in making his determinations on CAFE standards. The Department of Energy has the responsibility and the expertise to provide information and comments to the Transportation Department on two of those factors in particular-- both of which have been discussed above -- technological feasibility and energy conservation. The Department of Transportation then considers DOE's comments in the broader context of establishing standards that meet Congressionally mandated criteria.

The Administration is in the process of reviewing oil conservation policy options as part of its preparatory work for development of a national energy strategy. We intend to also, in consultation with other departments, examine options under existing authority to assess what, if any, legislative changes would be desirable. In addition, the role of improved fuel efficiency must be placed in the context of a broader energy strategy that combines a balanced mixture of energy efficiency improvements, increased domestic energy supply, and substitution of more reliable and diverse energy sources. The Secretary of

Energy is committed to the development of this integrated national energy strategy and has called for increased national attention to conservation.

This concludes my prepared remarks. I would be happy to entertain any questions that the Committee may have.



TRENDS IN FUEL PRICE AND AUTO MPG

1973–1989 (1986 $'s)

Senator METZENBAUM. Thank you very much, Dr. Berg. I think we will hear from all of the witnesses first, and we will open the floor to questions.

Mr. Richard Morganstern, we are happy to have you here this morning representing the EPA.

## STATEMENT OF RICHARD D. MORGANSTERN, DIRECTOR, OFFICE OF POLICY ANALYSIS, ENVIRONMENTAL PROTECTION AGENCY

Mr. MORGANSTERN. Mr. Chairman, I appreciate the opportunity to appear here this morning to discuss EPA's activities concerning global warming with particular reference to the fuel efficiency of autos. I ask that my prepared statement be submitted for the record, and I will summarize the key points.

In response to a request from the Senate Environment and Public Works Committee in late 1986, EPA has conducted a major study on policy options to limit greenhouse gas emissions. EPA was asked in the so-called Stabilizing Report to study the need for and implications of significant changes in energy policy, including energy efficiency and development of alternatives to fossil fuel, reductions in the use of CFCs, ways to reduce other greenhouse gases such as methane and nitrous oxide, as well as the potential for and effects of reducing deforestation and increasing reforestation.

The draft of this report, which is over 700 pages, has been completed. It is currently being reviewed by the agency's Science Advisory Board and by experts in other Federal agencies and outside government.

On March 17, EPA Administrator William Reilly testified before the Subcommittee on Environmental Protection of the Environment and Public Works Committee. He discussed at length the report's methodology and design, its limitations and uncertainties, the technological and policy options analyzed, as well as an overview of the report's findings. With your consent, I would like to submit Administrator Reilly's statement to this committee.

Turning to the climate issue itself, I'd like to put up a few charts.

The first chart depicts the greenhouse gases, such as water vapor, carbon dioxide, nitrous oxide and methane, which naturally occur in the atmosphere and serve as a virtual thermal blanket. This blanket traps some of the infrared radiation which is emitted back from the earth's surface thereby leading to warming. If there were no greenhouse gases, it is estimated that the earth would be approximately 30 degrees colder than it presently is. That's Celsius. Although there is uncertainty regarding the rate and magnitude of future warming, there is a scientific consensus that if the concentrations of greenhouse gases are increased above current levels, atmospheric temperatures will rise.

Turning to the next chart, we see that the atmospheric concentration of $CO_2$ has increased approximately 25 percent in the last 100 years in part due to fossil fuel combustion and industrial and agricultural activities. The National Academy of Sciences' Nirenberg Study Commission has estimated that the effect of doubling of the concentrations of $CO_2$ could eventually lead to a global warming of one and a half to four and a half degrees Celsius.

There are many human activities which serve as sources for emissions of greenhouse gases. Converting all the greenhouse gases to the common denominator of warming contribution allows comparison of the overall impact of various source categories. They are shown in my third chart. Energy production and use accounts for almost 60 percent of the current global contribution to greenhouse warming. That's the sector in orange. CFCs are the next largest category at 17 percent, followed by agriculture at 14, and deforestation and other land modifications at 9 percent.

Within the energy category, transportation energy use accounts for about a third of the energy impacts on warming, or 20 percent of the total warming contribution. Within the U.S. transportation provides a similar share of total warming.

Senator ROCKEFELLER. What are the other two-thirds?

Mr. MORGANSTERN. The other two-thirds are a variety of energy power use and a variety of other sources other than transportation.

Automobiles are the dominant component of transportation energy, over 60 percent of transportation energy use in the industrialized economies of the OECD. Although detailed and reliable energy use data are not readily available for non-OECD countries, it is believed that autos also account for a major though smaller share of transportation energy use in these countries.

Policies directed at improving automobile energy efficiency can make a significant impact on greenhouse gas emissions in the U.S. and globally. These options were given considerable attention in our draft report that is now undergoing review. Options for fuel economy improvements were not based on EPA analysis but rather were drawn from other published studies.

In the major policy cases examined in the draft report, a new car global fleet average fuel economy of 40 miles per gallon was assumed by the year 2000 with an average fleet miles per gallon of 50 by the year 2025; that is to say, new cars got 40 and the fleet was assumed to rise to 50 by the year 2025.

In a more aggressive policy scenario, we assume that the new car fleet average would reach 50 mpg by the year 2000 and that the average fleet would increase to 65 mpg by the year 2025.

In developing scenarios, we reviewed studies by the Department of Energy referenced by the previous speaker, the Office of Technology Assessment, the International Energy Agency and private consultants. These studies all suggest that significant improvements in fuel economy are technically achievable. Some of the studies address the actual economics of so doing.

In the EPA scenarios, the modified fleet average fuel economies were directly input to the model without explicit linkage to the particular mix of policies needed to achieve this result. The modeling effort was meant to illustrate the effects on global warming of major policy-related improvements in efficiency in automobile fuel use. A number of possible technical and policy options exist for achieving the fuel economy improvements that were actually studied in our report. These include fuel taxes, gas guzzler, and as they are referred to, sipper rebates, and the funding of research and development, as well as direct energy efficiency standards, such as CAFE.

I note that many of the studies cited as a basis for the fuel economy assumptions in our report have been criticized by manufacturers and others. Concerns raised include the costs, safety, consumer preference and other emission concerns. All of these issues must be addressed in detail in the context of developing policies to promote further fuel efficiency improvements.

In terms of reducing the threat from potential global warming, we believe and our draft report emphasizes that global cooperation will be essential to effectively reduce greenhouse gas emissions. As my final chart indicates, no single country or source will contribute more than a fraction of the emissions that contribute to the warming. Although the U.S. may have the highest per capita emissions, our share of total emissions is only about one-fifth of the global total. The EEC plus Japan contribute about another fifth, and the Soviet Union and East Bloc countries, although all the detail is not broken out in the chart, contribute about another fifth. So, the U.S. is a fifth, the EEC and Japan is another fifth, and the Soviet and East Bloc is the third fifth.

In this context, I am pleased to report that a good deal of activity is already under way internationally on the global warming issue. EPA and other Federal agencies are participating actively in the Intergovernmental Panel on Climate Change established under the auspices of the United Nations Environment Program and the World Meteorological Organization. We expect that some of our work on the stabilizing report will find application in this international process.

In summary, I believe that the results of EPA's analysis to date indicate that improvements in automobile fuel efficiency may be a significant factor in reducing the potential for global warming. Concerns have been raised about the practicality and specifically about the costs of policies to promote rapid fuel economy improvements. These concerns must be analyzed in detail. EPA will be placing a high priority on this detailed analysis in the coming months in cooperation with industry, other Federal agencies and international activities.

Thank you, Mr. Chairman.

[The prepared statements of Mr. Morganstern and Mr. Reilly follow:]

TESTIMONY OF
RICHARD D. MORGENSTERN
DIRECTOR, OFFICE OF POLICY ANALYSIS
U.S. ENVIRONMENTAL PROTECTION AGENCY
BEFORE THE
SUBCOMMITTEE ON ENERGY REGULATION AND CONSERVATION
COMMITTEE ON ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE

April 4, 1989

Mr. Chairman and Members of the Subcommittee, I am pleased to have this opportunity to discuss with you EPA's work evaluating options to reduce greenhouse gas emissions on a global basis and automobile fuel economy.

Greenhouse gases, such as water vapor, carbon dioxide, nitrous oxide, methane, and others, occur naturally in the atmosphere. They serve as a figurative thermal blanket, allowing solar radiation to pass through the atmosphere and strike the earth's surface, while absorbing some of the infrared radiation emitted back from the surface. This selective absorption of long-wave radiation warms the atmosphere and gives us our present climate. If there were no greenhouse gases, it is estimated that the earth would be approximately 30 degrees colder. If the concentrations of greenhouse gases are increased, the atmospheric temperature will increase.

There is scientific consensus that increases in atmospheric greenhouse gas concentrations will result in climate change. Atmospheric concentration of carbon dioxide has increased approximately 25 percent since about 1860, in part due to fossil fuel combustion and industrial and agricultural activities. The National Academy of Sciences' Nirenberg Study Commission has estimated that the effective doubling of the concentration of carbon dioxide in the atmosphere could eventually lead to a global warming of 1.5 to 4.5 degrees C. However, considerable uncertainty exists with regard not only to the timing, but also to the ultimate magnitude of any global warming. In addition, there is great uncertainty about how climate variability and regional climate patterns may change.

Improving fuel economy is one of many specific options discussed in the Environmental Protection Agency's draft report entitled, Policy Options for Stabilizing Global Climate. On March 17 of this year, Administrator Reilly discussed this report before the Subcommittee on Environmental Protection of the Committee on Environment and Public Works. He discussed at length the report's methodology and design, its limitations and uncertainties, the technological and policy options, as well as an overview of the report's findings. For additional information on these topics, I refer you to that statement.

**THE IMPORTANCE OF TRANSPORTATION**

There are many human activities which serve as sources for emissions of greenhouse gases. Converting all of the greenhouse gas emissions to the "common denominator" of potential warming contribution allows comparison of the overall impact of various source categories. Using this metric, energy production and use in all its applications accounts for almost 60% of the current global contribution to potential greenhouse warming. Within the energy category, transportation energy use accounts for about a third of the energy impact on warming or 20% of the possible total warming contribution. Within the U.S., transportation provides a similar share of potential total warming.

Automobiles are the dominant component of transportation energy - over 60% of transportation energy use in the industrialized market economies of the OECD. Although detailed and reliable energy use data are not readily available for non-OECD countries, it is believed that they also account for a major though smaller share of transportation energy use in these countries.

Improvements in automobile energy efficiency can have an impact on greenhouse gas emissions in the U.S. and globally. Options for fuel economy improvements were given considerable attention in the draft report. These fuel economy improvements were not based on EPA analysis, but rather drawn from other published studies. In the major policy cases examined in the draft report, a new global car fleet average fuel economy of 40 miles per gallon was assumed by the year 2000.

In a more optimistic scenario, EPA assumed that new car fleet average fuel economy would reach 50 miles per gallon by the year 2000, and that global fleet average fuel economy would reach 65 miles per gallon in 2025. This assumption resulted in additional reductions in global transportation energy use by the year 2025.

In developing scenarios, we reviewed studies by the Department of Energy, the Office of Technology Assessment, the International Energy Agency, and private consultants. These studies all suggest that significant improvements in fuel economy are technically achievable. Some of the studies address the economics.

In EPA scenarios, the modified fleet average fuel economies were directly input to the model without explicit linkage to the particular mix of policies needed to achieve this result. The modeling effort was meant to illustrate the potential effects on global warming of major related improvements in efficiency in automobile fuel use. A number of possible technical and policy options exist for achieving fuel economy improvements. These include fuel taxes, gas guzzler taxes and sipper rebates, and funding of research and development, as well as direct energy efficiency standards such as CAFE.

In addition, improvements in efficiency of fuel use in other transportation components are technically possible and potentially useful. Energy intensity of freight movement may be reduced through a combination of fuel efficiency improvement in trucks and rail and shifting freight to more efficient modes. Similar reductions in energy intensity in ships and aircraft may also be possible.

Several alternative fuels show promise in reducing greenhouse gas emissions as well as some other pollutant emissions of concern. Some fuels derived from natural gas, notably Compressed Natural Gas (CNG) could provide some improvement in greenhouse emissions relative to petroleum products. These fuels may be used in the next decade particularly for fleet applications in urban areas, primarily for their benefits in reducing urban air pollution. Of potential interest from the climate perspective are alcohol fuels (ethanol, and potentially methanol) derived from biomass. Again, near term interest in these fuels is being driven by broad environmental and energy security concerns. Nonetheless, these fuels may make a modest contribution to reductions in greenhouse gas emissions. Uncertainty still exists about the greenhouse effect of using CNG, primarily related to possible ethane emissions, which are a much stronger greenhouse gas per molecule than carbon dioxide. Similarly, any use of alcohol fuels must ensure that no environmentally significant additional carbon dioxide emissions result from the making of these products.

It should be noted that many of the studies cited as a basis for the fuel economy assumptions used in the EPA draft report have been criticized by automobile manufacturers and others. Concerns raised include the cost, safety, consumer preference and other emissions concerns discussed above. All of these concerns must be addressed in detail.

**NEXT STEPS**

In the immediate future, EPA expects that the extensive review and comment already underway on our draft report will improve our understanding of the quality and uncertainty of assumptions used in the analysis. Because of their prominence in the report, and obvious importance to the results, we hope that the draft policy options report will produce considerable comment by expert reviewers. The formal review process now underway will include comments by a distinguished panel of experts assembled by the EPA Science Advisory Board as well as detailed comments from other working groups under this Panel will be collecting and evaluating information on available policy options from all parties. In support of the Panel's activities and the concerns of its members the Organization for Economic Cooperation and Development is sponsoring a number of activities designed to facilitate sharing and comparison of information on both science and policy options among countries and organizations interested in climate change.

EPA is participating actively in these international endeavors, and expects to receive review and comment on our current and future work on technology and policy options. In addition, information developed in other countries will be identified and incorporated into EPA's ongoing analyses as appropriate.

In summary, I believe that the results of EPA's analysis to date indicate that improvements in automobile fuel economy may be a significant factor in reducing the potential for global warming. However, many concerns have been raised about the practicality and possible negative effects of policies to promote rapid fuel economy improvement. These concerns should be analyzed in detail. EPA will be placing a high priority on this more detailed analysis in the coming months, in cooperation with industry, other federal Agencies and international activities.

TESTIMONY OF
WILLIAM K. REILLY
ADMINISTRATOR
U.S. ENVIRONMENTAL PROTECTION AGENCY
BEFORE THE
SUBCOMMITTEE ON ENVIRONMENTAL PROTECTION
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS
UNITED STATES SENATE

March 17, 1989

Mr. Chairman and Members of the Subcommittee, I am very pleased to be given this opportunity to discuss with you the results of my recent activities concerning protection of the global environment, as well as the Environmental Protection Agency's draft report entitled, Policy Options for Stabilizing Global Climate.

## Global Environment Activities

We have made excellent progress on the stratospheric ozone issue over the last several weeks. As I am sure you are aware, the President announced his support of a phase out of chlorofluorocarbons by the year 2000 provided that safe substitutes are available, and I was able to take that position with me to Prime Minister Thatcher's London Conference on Saving the Ozone Layer.

That conference was an extraordinary event. To my knowledge, there has not been an environmental conference that involved so many countries -- over 120 in all, 80 at the ministerial level -- since the United Nations Conference on the Human Environment in Stockholm in 1972. The London conference is probably the single most important international environmental conference since that day, and as you know, it was the Stockholm conference that launched the international environment as a significant issue in many, many countries.

The London conference allowed us to share the latest in scientific research with a full spectrum of countries, including those that were not knowledgeable and those that were skeptical. It allowed all nations to hear of the rapid technological progress that has occurred since the Montreal Protocol was adopted in September of 1987. And, finally, it allowed us to share our views on some of the challenges that will face us over the next decade as we manage the transition to a CFC-free world.

Most gratifying was the response to the Montreal Protocol and to calls to strengthen its control measures. Thirty-six countries have now ratified the agreement, and an additional 20 announced at the Conference that they were actively involved in the ratification process. Ten more countries stated that, as a result of the information they received at the Conference, they would return home to urge active participation in the Protocol. This is most encouraging.

Equally encouraging were the statements of much of the developed world in favor of a phase out of the chemicals that deplete the ozone layer. The European Community announced its position of a phase out of CFCs by the turn of the century, and similar views have been expressed by each individual European country, the Nordic countries, and several of the developing countries that are parties to the Protocol. This will help us to move forward together quickly to revise the control provisions of the international agreement.

The Administration will work to achieve worldwide ratification of the Montreal Protocol. Actions taken by the developed countries to protect the ozone layer are not sufficient; we must assure that all countries join together in this effort.

During the Conference, I met personally with the delegations of China, India, Brazil, Sri Lanka and other developing countries. The needs of the developing world for financial assistance are very real and very important, and I came away from the meeting with the conviction that we must move positively to deal with these concerns. As you may know, we have already begun to work with the World Bank on this issue, and are encouraged by their initial response. We are also exploring new directions with other multilateral and bilateral aid agencies, and hope to have some concrete suggestions for the developing world at the first meeting of the Parties to the Protocol that will be held in Helsinki in May.

The Helsinki meeting will, I believe, move the process of reconsideration of the Protocol even farther. The Montreal Protocol requires that four assessments be completed before the Parties make decisions to change specific control provisions. These four assessments, one on atmospheric science, one on environmental effects, one on technology, and one on economics, have already begun. In Helsinki, we will hear from the lead countries on the progress they have made on these assessments. We have every expectation that they will all be completed as scheduled in August of this year, and that a meeting can be held in September for a group of the Parties to prepare recommendations for amendments to the Protocol's control provisions. As the Protocol requires, the recommendations will be circulated to all the Parties, and a decision on strengthening the Protocol can be made at the second meeting of the Parties that is scheduled for April of 1990.

But the Helsinki meeting will be important for other reasons as well. I believe very strongly that managing the transition to substitute chemicals and processes is of critical importance. We must be sure that in our effort to move expeditiously to eliminate the production and use of the controlled substances, we do not create other environmental problems. Our concerns for toxicity, global warming, and the total protection of the ozone layer are all important, and we hope to discuss each of these concerns at the meeting in Helsinki.

It is critical that we take every precaution to ensure that the substitutes for CFCs and halons are not toxic. In the United States, we have authority to require comprehensive testing and analysis of the new chemicals under the Toxic Substance Control Act. We intend to use that authority where it is appropriate.

We also must be sensitive to the close connection between CFCs and global warming. In reducing our dependence on CFCs and halons, we must ensure that new technologies do not result in decreased energy efficiency. While the primary purpose of the Montreal Protocol is to protect the ozone layer, reducing CFC emissions may also have the added benefit of slowing the growth in greenhouse gases that contribute to global warming. According to our current estimates, a phase out of CFCs might reduce the amount of global warming by as much as 15 percent. However, if the CFC substitutes result in less energy efficient products, fossil fuel usage, which contributes to greenhouse gas emissions, would increase. Therefore we must ensure that in shifting from CFCs, we do not have an equally adverse effect on this critical global environmental problem.

Finally, we must be sure that our actions effectively respond to the threat of ozone depletion. That means carefully examining the issue of how much chlorine and bromine the atmosphere can safely absorb. This may be the most difficult challenge we face. We will have to balance the need to eliminate the most harmful ozone-destroying chemicals with the recognition that some of their replacements are likely to contribute small amounts of chlorine to the atmosphere, and that their use may be necessary at least for some period of time. We must also consider whether limits are warranted on other chlorine-containing compounds, such as carbon tetrachloride and methyl chloroform, which are not now covered by the Protocol's control provisions.

The agenda for the meeting in Helsinki is, as you can see, a very full one. Over the next several weeks, we will be discussing our analyses of these critical issues with industry and with the environmental community. Our interest, like yours, is to see that we move both as quickly and as prudently as is possible. We hope to work with you as we move forward on this path to protect our fragile environment.

## Policy Options for Stabilizing Global Climate

### CONGRESSIONAL REQUEST FOR REPORTS ON GLOBAL CLIMATE CHANGE

The Committee requested in 1986 that EPA develop two reports on global warming. One report was to focus on "Policy options that if implemented would stabilize current levels of greenhouse gas concentrations." The second report was to examine "The potential health and environmental effects of climate change including, but not be limited to the potential impacts on agricultural, forests, wetlands, human health, rivers, lakes, estuaries as well as societal impacts."

In response to the Congressional Directive, EPA prepared a draft report entitled, Policy Options for Stabilizing Global Climate that I will discuss today. This report investigates technological and policy options for stabilizing and reducing greenhouse gas emissions.

The draft EPA Report is a first attempt to comprehensively analyze alternative policy options to limit greenhouse gas emissions on a global basis. This study has been conducted over the past two years and has been a major undertaking for us. I am quite pleased with the product. At the same time, I must caution the Committee and the public at large, that this is, in fact, a draft study. While various experts within the government and outside have participated in the study, it has not yet been peer reviewed by the Agency's Science Advisory Board or by the experts in other Federal agencies and it is quite clearly subject to change.

## THE STABILIZATION REPORT

This report is the result of a major two-year study of the policy options available to stabilize current levels of atmospheric greenhouse gas concentrations. The study produced a comprehensive summary of estimated greenhouse gas sources and trends in concentrations. The major sectors contributing to emissions (energy, industry, agriculture and forestry), and the major greenhouse gases ($CO_2$, $CH_4$, $N_2O$, and CFCs) are considered on a global basis. The study examines various domestic and international policy options that, if implemented, could slow the buildup of greenhouse gases which may contribute to global climate change, including the phasing out of CFCs, halting deforestation and initiating reforestation, increasing use of natural gas, increasing energy efficiency in transportation, buildings and industry, and developing non-fossil fuel technology. The primary focus of this review is to identify policy options that appear promising. The report has not made a detailed assessment of the costs and other economic aspects of these options. It was impractical to complete such an assessment in this report. However, we view cost and other economic considerations to be of major importance. As part of an international effort, options must reconcile the requirements for both sustainable economic development and a safe environment. Therefore, they should be as cost-effective as possible. The report also suggests future research activities that would improve our understanding of the sources of greenhouse gases and areas where technological improvements would reduce the emission of these gases.

## Sources of Greenhouse Gases

Many diverse sources have contributed to the increase in greenhouse gas concentrations, including the burning of fossil fuels, deforestation, and, over the past 40 years, the use of synthetically produced chlorofluorocarbons (CFCs). $CO_2$ is currently a significant greenhouse gas, responsible for about half of our current increases in our commitment to estimated future warming, but many other gases contribute to global warming-- CFCs, methane ($CH_4$), and nitrous oxide ($N_2O$).

All greenhouse gases have multiple sources. The primary anthropogenic sources of $CO_2$ are fossil fuel combustion and deforestation. Major methane sources are rice production, enteric fermentation in domestic animals, biomass burning, fossil fuel production, and anaerobic decomposition in landfills. Major $N_2O$ sources are nitrogenous fertilizer use, land clearing, biomass burning, and fossil fuel combustion.

Greenhouse gases are emitted in both the developed and less developed countries. Scientists currently estimate that approximately three-quarters of $CO_2$ emissions from anthropogenic sources come from the burning of fossil fuels, and one-quarter results from deforestation -- largely in tropical countries. Western Europe and North America account for approximately forty percent of fossil fuel emissions, but since the early 1970s, their emissions have remained relatively stable. In fact, the United States' fraction has been decreasing. The Soviet Union and Eastern Europe, the People's Republic of China, Pacific rim countries and developing countries contribute approximately sixty percent of fossil fuel emissions. And, most importantly, their share is rising. With regard to other greenhouse gases, approximately three-quarters of the CFCs are produced in North America and Europe, while major anthropogenic sources of methane are associated with rice production in Asia. Thus, all countries contribute to greenhouse gas emissions and share some responsibility for their continuing growth.

Study Design

EPA established several program goals in developing the "Stabilization Report": (1) assemble data on global trends in emissions and concentrations of greenhouse gases; (2) develop an integrated analytical framework to study how economic, policy and scientific assumptions influence warming estimates; (3) identify promising technologies and practices that have the potential to limit greenhouse gas emissions; and (4) identify policy options that could slow the buildup of greenhouse gases which may contribute to climate change. To achieve these goals, EPA conducted an extensive literature review and data gathering process. The Agency held several informal panel meetings, and enlisted the help of leading experts in the governmental, non-governmental, and academic research communities. EPA also conducted five workshops to gather information and ideas regarding factors affecting atmospheric composition and options related to greenhouse gas emissions from agriculture and land-use change, electric utilities, end-uses of energy, and developing countries. Experts from NASA, the Department of Energy and the Department of Agriculture were consulted.

Based on the results of this process, EPA developed an integrated analytical framework to organize the data and assumptions required to estimate (1) emissions of radiatively and chemically active gases; (2) concentrations of greenhouse gases; and (3) changes in global temperatures. The framework, though highly simplified, permits alternative assumptions to be made concerning population growth, economic growth, technological change, and emissions reduction strategies.

In developing our report, we recognize that many factors will influence future greenhouse gas emissions, including rate of population growth, economic growth, technological change, fuel mix, and energy, industrial and agricultural policies. To broadly account for these factors, EPA developed four scenarios of possible future worlds for analysis. Two scenarios assume that no policies are adopted to reduce the emission of greenhouse gases--one assumes that future economic growth and technological change are rapid (Rapidly Changing World or RCW) and one assumes economic growth and technological change are slow (Slowly Changing World or SCW). Both of these scenarios have analogous counterparts which assume that stabilizing policies are adopted (RCWP and SCWP).

## Limitations and Uncertainties

This analytical framework models some of the major processes that will influence the rate and magnitude of greenhouse gas accumulation during the next century within a structure that is suitable for policy analysis. There are however, a number of major limitations to this framework. First, assumptions are made in the framework about rates of economic growth and technological change, which strongly influence forecasts of future greenhouse gas emissions. But economic growth and technological change are difficult to forecast. Second, detailed economic and cost analyses were not conducted. We did not attempt to calculate the macroeconomic impacts of policy options or the total costs associated with various strategies. However, promising technologies were qualitatively screened based on judgments of their expected cost-effectiveness. Third, limitations on capital investment were not explicitly considered. Fourth, economic feedbacks are not fully represented. Finally, our attempts to depict the ocean, changes in atmospheric chemistry, and biogeochemical feedbacks are highly simplified. In summary, we attempt to present our results with all of the uncertainties about the economic system and physical climate system fully recognized.

## GENERAL CONCLUSIONS

Uncertainties regarding the magnitude and timing of climatic change are large, but there is a growing consensus in the scientific community that global warming, perhaps of significant degree, due to anthropogenic emissions of greenhouse gases is probable, and rapid climatic change over the next century is possible. Within EPA's scenarios, if no policies to limit the emission of greenhouse gases are undertaken, the equivalent of a doubling of $CO_2$ is estimated to occur between 2030 and 2040, and the earth warms by 2-6°C by the end of the 21st century.

Very large reductions in anthropogenic emissions would be necessary to stabilize atmospheric concentrations of greenhouse gases. EPA's scenarios do not achieve these reductions, but rather examine a mix of policy responses to limit emissions of greenhouse gases that could significantly reduce the estimated rate and magnitude of climate warming.

Policy and technological measures to limit greenhouse gas emissions are estimated to decrease the magnitude and speed of projected global warming, regardless of uncertainties about the response of the climate system. With such global policy measures, the report estimates that the rate of global warming could be significantly limited over the next century, perhaps by one half or more of the warming that is estimated to occur without policy intervention.

Global cooperation will be essential to effectively reduce greenhouse gas emissions. No single country or source will contribute more than a fraction of the greenhouse gases that may contribute to global climate change. Any overall solution to the climate change problem will require cooperation of many countries and reductions in many sources. For example, postponement of action by developing countries to reduce greenhouse gas emissions would severely hamper the effectiveness of any reduction by developed countries.

The report considers a wide range of potential policy options to reduce greenhouse gas emissions. Although detailed economic analysis was not conducted, we believe that some emissions reductions are possible while promoting economic development, environmental, and social goals. In industrialized countries, acid rain, urban ozone, and dependence on imported energy could be reduced as part of an overall strategy that reduces greenhouse gas emissions. Energy efficiency improvements are important all over the world. In some developing countries efficiency improvements may actually reduce capital requirements in the power sector and encourage long term economic development. Carefully designed efforts to halt deforestation in developing countries could possibly provide long-run economic and environmental benefits, in addition to reducing the emission of greenhouse gases.

Technological and Policy Options

Various technological and policy options were evaluated for their estimated effectiveness in reducing the projected rate and magnitude of global warming. No single technology or policy can have a significant impact in mitigating the accumulation of greenhouse gases because of the wide variety of sources. But, the models predict that many individual measures, each having a modest impact on greenhouse gas emissions, can have a significant impact on the estimated rate of climate change when combined. The model results imply that only by aggregating the effects of many technical opportunities over a long time can significant reductions in greenhouse gas emissions be achieved. This implies that any overall strategy to reduce greenhouse gas emissions must seek the right combination of pricing, regulation, technological development, procurement, state programs, and information transfer.

Let me speak about a few of these options. Although we have not conducted detailed economic estimates, there is an extensive literature indicating that improvements in end-use-energy efficiency provide the best option for reducing $CO_2$ emissions over the next few decades. Reductions in energy use would also reduce emissions of $CH_4$, $N_2O$, $NO_x$, and CO. Many efficiency improvements are possible by the year 2000. These include improvements in the transportation sector, accelerated improvements in building shells, lighting, space conditioning and appliances. All of these could significantly reduce energy requirements.

Near-term reductions in greenhouse gas emissions from electricity generation are possible through both efficiency improvements and fuel switching. Improved fossil electricity generation technology, such as advanced combustion turbines and cogeneration, can increase the efficiency of using these fuels by up to 25 percent. Also, the use of more natural gas to displace coal as a fuel for generating electricity could reduce $CO_2$ emissions by a substantial amount in the near term.

Alternative fuels, such as hydroelectric, biomass, solar, geothermal, wind, and nuclear, do not emit significant amounts of greenhouse gases and could make an important contribution to reducing these emissions in the medium term and could virtually eliminate many categories of emissions over the long term. For widespread use of alternative fuels, important engineering, economic, environmental and social issues must be resolved.

Reforestation may offer one of the most attractive options for reducing net $CO_2$ emissions. Preliminary estimates of the feasibility of large-scale reforestation suggest that with aggressive reforestation programs, the current deforestation trend could be reversed and that a significant net increase in forest biomass is possible.

Improvements in agricultural production efficiency could reduce emissions from those sources. Increasing the efficiency of fertilizer use, productivity of livestock systems, and productivity of rice cultivation could decrease the emission of greenhouse gases per unit of agricultural product. Also, reducing the amount of biomass burning associated with agriculture through sustainable agriculture and effective utilization of crop residues would reduce the emission of greenhouse gases.

According to our current estimates, a phase out of CFCs could reduce the amount of global warming by as much as 15 percent.

## Research Needs

The Report defines the major uncertainties relating to climate change, and indicates research needs to both resolve these uncertainties and reduce greenhouse gas emissions. The

Administration is moving ahead to expand research in this area. The President's Budget requested increased resources for a directed and coordinated global change research program. The report suggests that future research activities focus on the characterization of sources of greenhouse gases, climate system feedback analysis, and development of improved ocean circulation models. In addition, research and development is needed to improve our options for limiting greenhouse gas emissions. There is a need for the development of new technologies in the areas of CFC substitutes, energy efficiency (including lighting, industrial processes, vehicles, and insulating materials), alternative fuels (biomass, solar, nuclear, hydrogen, and energy storage techniques), agricultural practices (livestock management, rice production, and biomass burning), and forest management.

NEXT STEPS

As more countries recognize that no single nation acting alone can decisively affect the greenhouse gas problem, international organizations have increasingly become involved in the climate change arena. These include the United Nations Environment Programme (UNEP), the World Meteorological Organization (WMO), and the International Council of Scientific Unions (ICSU). The most significant recent event has been the establishment by WMO and UNEP of the Intergovernmental Panel on Climate Change (IPCC).

The first meeting of the IPCC was held in November 1988, with over 30 countries participating. The IPCC established three working groups to 1) assess available scientific information on climate change; 2) assess the possible environmental and socio-economic impacts of climate change; and 3) formulate possible response strategies. The working group on science is chaired by the United Kingdom. The working group on impacts is chaired by the Soviet Union. And, the United States chairs the working group on response strategies.

In late January 1989, the United States hosted the first meeting of Working Group III. The meeting was introduced by Secretary of State James A. Baker III, who made four points: first, that we can probably not afford to wait to resolve all uncertainties before acting; second, that we should focus immediately on steps which are justified for other reasons, including reduction of CFC emissions, greater energy efficiency, and reforestation; third, that global solutions should be as specific and cost-effective as possible; and fourth, that solutions must reconcile the requirements for both economic development and a safe environment. The three day session ended with the adoption of an ambitious work plan. The plan includes the development of adaptive and emission limiting responses for agriculture, industry, natural resources, and coastal zones. The EPA was an active participant in this entire process along with other agencies. The Agency expects to play a very active role in the IPCC process in the future.

EPA, along with other Federal agencies, intends to continue to be an active participant in the formulation of a Federal research agenda, in the conduct of research that improves our understanding of the earth's climate system and that supports the needs of policymakers, and in future debates over strategies to adapt to climate change or to limit emissions.

The development of a national policy, as mandated under the Climate Protection Act, will be complex and the formulation of a coordinated international response may take a great deal of effort. Much work remains to be done by the research community to understand emissions, the interactions of emissions with the biosphere, and the ultimate effect on man and the environment of increasing greenhouse gas emissions levels in the atmosphere. At EPA, we intend to examine the prudent steps that can be undertaken to achieve multiple goals, and do so in a timely manner. In the future, we will do a great deal more to examine the cost of different options and the technological, cultural, and political barriers to implementation of policies. EPA looks forward to working with interested federal agencies, and others, and to the exchange of research and policy findings with other countries.

Mr. Chairman, thank you for your invitation to present testimony before the Committee. This has been a welcome opportunity to discuss EPA's efforts on this important and complex issue. I would be pleased to answer any questions you may have.

Senator **Metzenbaum**. Thank you very much, Mr. Morganstern.

The third and last witness of this panel is Mr. Howard Smolkin, Managing Director of the National Highway Traffic Safety Administration, the Department of Transportation. Mr. Smolkin?

## STATEMENT OF HOWARD M. SMOLKIN, MANAGING DIRECTOR, NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION, DEPARTMENT OF TRANSPORTATION, ACCOMPANIED BY BARRY FELRICE, ASSOCIATE ADMINISTRATOR FOR RULEMAKING

Mr. **Smolkin**. Thank you, Mr. Chairman.

Mr. Chairman and members of the committee, I am pleased to appear before you today to discuss the issue of motor vehicle fuel economy standards. With me at the table is Barry Felrice, our Associate Administrator for Rulemaking.

My remarks today will be brief.

Secretary Skinner is presently reviewing the issues raised in a pending rulemaking concerning whether to reduce the corporate average fuel economy standard of 27.5 miles per gallon to a level between 26.5 and 27.5 miles per gallon for the 1990 model year. Until the Secretary has made his decision, statements on behalf of the Department will necessarily avoid positions that could be construed as indicating the Secretary's intent.

Having said this, I want to assure you that the Secretary is mindful of the issues of energy conservation and the environment. The fuel efficiency of motor vehicles is one of a wide range of issues relating to the energy conservation and the national economy that the new administration has begun reviewing.

The United States has made major improvements in fuel economy over the past decade to the point where the fuel economy of the new car fleet in the past three years has exceeded the 27.5 miles per gallon goal set by the Congress. The question of how to make further gains will require a consideration of a multitude of factors: economic practicability; technological feasibility; possible tradeoffs regarding safety, comfort, passenger carrying capacity and performance; environmental effects; impacts on domestic employment; and the effects on the U.S. economy, as well as energy conservation.

The Department of Transportation will be discussing these matters with the Environmental Protection Agency on environmental issues; the Department of Energy on fuel conservation needs, the Department of Commerce on jobs and competitiveness and other departments and agencies.

Upon the Secretary's decision in the rulemaking regarding the CAFE standard for model year 1990, we will be in a better position to discuss the issues raised by the various legislative proposals to increase the CAFE standard for future model years beyond 27.5 miles per gallon.

By way of general comment about legislation affecting fuel economy, we note that first the Department currently has sufficient regulatory authority to amend the passenger car and light truck standards. And, second, the setting of any standard should be based on an assessment of the feasibility of achieving the standard considering the factors I have enumerated above.

Mr. Chairman, this concludes my remarks. Within the limits described, we will be glad to try to answer any questions.

Senator **Metzenbaum**. Thank you very much.

The Chair will adopt a 10-minute rule for questions, and if necessary, we'll have more than one round.

I have one simple question for you, Mr. Smolkin, and that is how soon do we expect the Department of Transportation to have all these consultations and come up with a policy?

Mr. **Smolkin**. The Secretary has treated the energy conservation issue as one of his highest priorities. While I cannot give you an exact date, we do expect a response fairly shortly.

Senator **Metzenbaum**. Do you mean within a month or so?

Mr. **Felrice**. Mr. Chairman, if I can, I think the immediate issue before the Secretary is whether to amend the statutory 1990 model year standard of 27.5 miles a gallon. And I would expect that that decision could be made before the end of this month.

And I think that decision has to be a precursor to an administration policy on future possible increases in fuel economy standards. And with that, we will have to coordinate with our colleagues at the table, with EPA and DOE. I would presume that that would take more than a month. It would be a few months to develop that and do the analyses that everyone at this table has mentioned.

Senator **Metzenbaum**. Let me suggest that you take back to the Secretary our thoughts that there is some sense of urgency. We would like you to proceed as promptly as possible. We know that the Secretary has a lot on his plate at the moment, but notwithstanding that, we think this does have some urgency.

Secretary Berg, the EIA predicts in their latest forecast U.S. oil imports will climb above 10 million barrels per day and exceed 50 percent of consumption in the next decade. President Reagan in his last week in office officially declared that oil imports are a threat to the Nation's security.

Do you agree that oil imports constitute a threat to the national security?

Dr. **Berg**. Yes, sir.

Senator **Metzenbaum**. President Reagan and President Bush have said the best way to address the problem is to stimulate oil production. President Bush submitted four oil production incentives to Congress.

Has the DOE compiled their estimates of how much production they are expected to yield if Congress were to enact them?

Dr. **Berg**. All this is being studied right now, Mr. Chairman, in preparation for a national energy policy.

Senator **Metzenbaum**. Do you have any idea when that will be enunciated?

Dr. **Berg**. We anticipate that in the late summer, the August-September time frame.

Senator **Metzenbaum**. Has the DOE completed estimates of the reduction in consumption which would result from efficiency standards rising to 35 or 40 miles per gallon, and what are those predictions?

Dr. **Berg**. We have done a number of studies and made a number of estimates. I believe the ones that you are referring to were after 1995, somewhere in the area of the year 2000, and that mileage would be over 35 miles to the gallon. Those studies, of course, depended upon a number of factors, including the fact that we are making estimates based on today's mix of vehicles, based on today's preferences as far as performance is concerned and also in that range that there would be other increases in technology that would provide additional fuel economy over a 35 mile range beyond 1995.

Senator **Metzenbaum**. Do you have any comment to offer on that, Mr. Morganstern?

Mr. **Morganstern**. No.

Senator **Metzenbaum**. Four years ago William Silvey, DOE Deputy Assistant Secretary for Policy, Planning and Analysis, testified before this subcommittee on the subject of automobile fuel economy. He said in response to my questioning—and I quote—"Mr. Silvey, My personal view is that within a couple of years that it will be irrelevant because at that point where I feel the industry is by 1987. I think they will all be above 27 and a half and I think they will continue to go up."

I would just say for the record that shortly after this hearing four years ago, the Reagan Administration rolled back the CAFE requirement as far as the law would allow. And the domestic auto makers did not all exceed 27 and a half miles per gallon in 1987.

On January 28, 1988, I cosigned a letter from Mo Udall and Senator Stafford and several other Members to Energy Secretary John Herrington asking for analysis on several options for improving automobile fuel economy. Secretary Herrington's response included an analysis memorandum entitled The Role of Fuel Efficiency and Decreasing Oil Dependence.

My question is: are you or the personnel accompanying you familiar with that memorandum?

And while the memo made it clear that achieving 45 or 60 miles per gallon by 1995 would entail some sacrifices, it also made a convincing case that new car fleet fuel economy well above 27½ miles per gallon is achievable by 1995 with very little, if any, sacrifice in the mix between the large versus small cars in performance or in cost effectiveness.

My question is: the analysis memorandum described a market case which showed that with gasoline at $1.12 per gallon in 1995, current technologies could be used cost effectively to achieve a new car fleet average in the U.S. of 32 miles per gallon by 1995. Would you agree with that?

Dr. **Berg**. The EIA recent study indicated that they felt a 31.8 mile per gallon was feasible by 1995. Again, that assumes a present mix. It also assumes that the consumer doesn't opt for greater performance than what they are currently; in other words, that whole mix area would stay the same.

Senator **Metzenbaum**. Do you feel that—what impact would there be if the mix included a substantially lesser number of large cars?

Dr. **Berg**. If it were less, again it would depend upon a number of factors, including what people did as far as performance is concerned and potential other non-fuel economies that might have to be added as a result of other regulations. For instance, if the refrigerant is eliminated from the air conditioning system, currently the next alternative is less efficient and would require more gasoline used in the air conditioner. There's a number of things like this that could affect those results.

The other problem, of course, that was looked at by EIA was of the technologies that would be included such that if, for instance, four-valve, four-cylinder engine would they have the same performance as a standard two-valve, six-cylinder engine currently, and would the customer opt for the increased fuel efficiency. However, if the customer preferred to have greater performance and remain at the same fuel level, they could go to a four-valve, six-cylinder engine which would essentially have the same amount of gasoline burned per mile as the current six-cylinder, two-valve engine has.

Senator METZENBAUM. What is the percentage of production of diesel cars today and what impact does that have?

Dr. BERG. Diesel cars could have an impact. We never have in any of our studies used diesel engines as part of the fuel mix up to 1995. Diesel engines do have certain advantages. They have certain disadvantages, including some problems that caused consumers to back away from the use of diesel engines in the number of automobiles that have been on the road, cold weather starting being one of the problems that has not been totally overcome to the customer satisfaction.

Senator METZENBAUM. When we discussed this matter earlier—and I forget when it was exactly—there was some reference to the fact that many of the high priced foreign imports are not really that concerned about what our laws are because they are prepared to pay the additional cost. As I see it, it's a rather minor cost as compared to the price of a Jaguar or Mercedes or Rolls or whatever the case may be. And as I see it, it's $5 per one-tenth of a mile per gallon per car. So, if you miss it by five miles, you are only paying $250 a car. Do you think we ought to be addressing ourselves to that aspect of the problem?

Dr. BERG. At this point I'm representing the new Administration and my personal views don't count sir, and I would pass on answering that question.

Senator METZENBAUM. If you can obtain an answer for the committee on that subject——

Dr. BERG. It certainly is being looked at by the Administration, and we'll provide it when it's available.

Senator METZENBAUM. And I would ask the Department of Transportation to do the same.

Mr. SMOLKIN. Yes, sir. We would be happy to.

Senator METZENBAUM. Mr. Morganstern, Ford Motor Company's testimony says that doubling the fuel economy of the U.S. new car fleet would have only a .5 percent effect on the buildup of global warming gases. Do you agree with this assessment, and how important would a doubling of the fuel economy be on the effort to stabilize global warming?

Mr. MORGANSTERN. Mr. Chairman, our study examined the number of issues that are quite relevant to that topic. As I indicated earlier, our study is undergoing a review. And I will address the answer to your question, but I would just caution you that my answer might need to be qualified by some subsequent review of the study.

Our estimate, with that caveat, is that the contribution of U.S. automobiles is about 2 to 3 percent of the global contribution to greenhouse warming. Thus, a doubling of the fuel economy in the U.S. alone—the U.S. alone—would reduce the total contribution to global warming by about 1 to 2 percent by the time the vehicle fleet turns over.

Now, this estimate of 1 to 2 percent is dependent on many things. Some of them Mr. Berg mentioned. Others, of course, depend upon consumers' response in terms of actual driving patterns.

However, it should be recognized that the U.S. is the world's largest market for automobiles. Thus, requirements in the U.S. would be expected to have considerable spillover effect in encouraging overseas manufacturers to produce higher efficiency automobiles.

I should also point out for the record, Mr. Chairman, that our study did not look at unilateral action by the United States. We looked only at changes in the global average which would affect all nations.

Senator **METZENBAUM**. One more question for you, Mr. Berg. Your study assumed that the technologies were cost effective in terms of the first purchaser of the first four years of ownership. What happens if you ask that fuel economy technologies implemented in the car be cost effective for the life of the car, not just for the first four years? That lets you achieve a higher fuel economy, does it not? And what about the 35 mile per gallon question?

Dr. **BERG**. Well, certainly the greater the economy over the life of the car, the more fuel will be saved. I believe that the four year was taken on the average of what the average first buyer would experience. The average consumer holds a car for four years. I have to say that I'm not an average consumer because I tend to drive mine for well over 100,000, nearly 200,000 miles. And certainly during that time, the greater the fuel economy that is exhibited by the automobile, the greater the savings would be.

Dr. Difiglio, would you care to add to that?

Dr. **DIFIGLIO**. Thank you.

Yes, Senator Metzenbaum. The increase of the discount period from a 4-year to a 10-year period, which would represent the average expected life of the vehicle, will increase the level of fuel economy which is cost effective to all users of the car as opposed to the first owner. We estimated, using the assumptions we had in that memorandum, that for the first owner for four years, the fuel economy that would be most optimal would be 32 miles per gallon, and then also in that memorandum, a higher figure was estimated for an owner of 10 years. This estimate was recently revisited and raised to 35 miles per gallon.

So, our current estimate of what is cost effective for all owners of the vehicle over a 10-year period is 35 miles per gallon given the assumptions of constant market mix remaining as it was in model year 1987 and the vehicle weight remaining constant as it was in 1987 and vehicle performance levels remaining constant.

All of those factors could change between now and model year 1995, and as those factors do change, we will continually revise that estimate to account for current trends in automobiles.

So, I would therefore like to qualify that estimate by saying that it's a bench mark estimate made in order to present some analytical information. It's not a projection of what we actually think could occur or should occur in model year 1995 because that depends on many factors which are most importantly affected by consumer choice.

Thank you.

Senator **Metzenbaum**. Thank you.

At this point I'm going to insert in the record a letter to Representative John Dingell from Acting Secretary Donna Fitzpatrick dated February 14, 1989, with some attachments which make similar arguments on auto fuel economy.

[The information referred to follows:]

Lim

**Department of Energy**
Washington, DC 20585

February 14, 1989

Dear Mr. Chairman:

This responds to your letter of December 8, 1988, regarding the development and commercialization of ceramics for motor vehicle use and the impact of new technologies on fuel economy, safety, and emissions.

The Department of Energy (DOE) has conducted a major effort with heavy industry involvement since the 1970s focused on development of advanced automotive engines and technology. As part of that effort, the development of ceramics for commercial applications in engines and other energy conversion systems has been one of our highest priorities. Responses to your questions relative to these program activities and areas of DOE responsibility are contained in the enclosure.

If there is any additional information that you may desire, please let me know.

Yours truly,

Donna R. Fitzpatrick

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Acting Secretary

Enclosure

Honorable John D. Dingell
Chairman, Subcommittee on
Oversight and Investigations
House of Representatives
Washington, DC 20515

cc: Honorable Thomas J. Bliley, Jr.
Ranking Minority Member
Subcommittee on Oversight and
Investigations
House of Representatives
Washington, DC 20515

Enclosure

Information Responding to
Letter Dated December 8, 1988 From
U. S. House of Representatives
Committee on Energy and Commerce
Subcommittee on Oversight and Investigations
John D. Dingell, Chairman

January 18, 1989

**Question 1: What is the "priority" given by the U.S. Government and industry since 1980 to the development and commercialization of ceramics in the U.S.?**

**Answer:** The development and commercialization of ceramics has been a high priority of the Department of Energy (DOE) since well before 1980. Beginning in the late 1970's DOE initiated a major effort focused on development and fabrication of ceramic components as part of the advanced heat engine program. Industry interest in the United States remained fairly low since the feasibility and reliability of using ceramic materials in automotive engines had not been demonstrated.

In the early 1980's the DOE engine programs began to demonstrate the feasibility of ceramic components for application to automotive engines, and also to identify basic technology needs necessary before the reliability of ceramic products were adequate for commercialization. At the same time the Japanese Government initiated a national effort involving many industrial participants to develop and promote advanced ceramics. Both of these events raised the level of U.S. industrial interest.

During 1982-1983 DOE conducted a detailed assessment on the technology development requirements for reliable heat engine ceramic components involving the ceramic industry, the heat engine industry, government laboratories and universities. As a result of that assessment an Advanced Materials Development Program was initiated in 1983 with the objective to establish a fundamental ceramic and advanced materials technology base to support the heat engine industry. A primary strategy of the program was the heavy involvement of U.S. industry in both the planning and implementation of the research and development projects.

In 1985 the United States Advanced Ceramics Association (USACA) was formed to promote and coordinate industrial commercialization of ceramic products. The association currently has 36 industry members, and all are actively engaged in the commercialization of near-term ceramic parts. Attachment A is a report which describes the USACA organization and its present membership.

The development and commercialization of ceramics in the U.S. is currently a high priority for both Government and industry. DOE ceramic development programs involve all of the major U.S. ceramic suppliers, and industry cost-sharing now averages over 25 percent. Industry is investing internal funds to commercialize near-term products from the technology developed under the Government programs, and many of those products are forecast for commercial introduction during the next two years. Under the DOE program, a user oriented High Temperature Materials Laboratory (HTML) has been constructed at Oak Ridge National Laboratory to meet the research needs of industry and the scientific community for advanced high-temperature materials, including structural ceramics and alloys. Attachment B, "Tenth Annual Report to Congress on the Automotive Technology Development Program", describes the automotive advanced engine and ceramic development activities under way at DOE. Attachment C, High Temperature Materials Laboratory First Annual Report, describes the HTML facilities and user activities.

Question 2: Are we still competitive? What is the status of ceramic development and commercialization in Japan, the U.S., and elsewhere?

Answer: In general, most experts feel that the United States is behind Japan in development and commercialization of ceramics particularly in the area of manufacturing technology. In 1988 DOE completed a world-wide economic assessment through Argonne National Laboratory which was focused on the application of ceramics to heat engines. The assessment asked a large number of industrial and ceramic experts around the world for their judgments and forecasts related to specific applications of heat engine ceramics. A two-stage Delphi approach was utilized, and questions related to the state of international competition in developing the technology were also included.

The results of the Argonne study indicate that Japan leads in commercial processing areas, and that the United States leads in basic research and advanced technologies. The size of the market for automotive ceramics is forecast to be extremely large, and it is expected that Japan's share of the world market by the year 2000 will be 40 percent compared to a United States share of 25 percent. Attachment D, "The Application of Ceramics to Heat Engines: An Economic Assessment Based on the Worldwide Delphi Survey", and Attachment E, "The Outlook for Ceramics in Heat Engines, 1990-2010", are copies of documents describing the assessment and its results.

Question 3: What is the extent of the research effort in the U.S. and Japan in dollars by government and the private sector?

Answer: The extent of the research effort in the U.S. and Japan by government and the private sector is known in general terms, but funding information is incomplete and not entirely comparable. Our best judgment is that the Japanese research effort is at least double the U.S. effort. This judgment is based on both recent budget information about the Japanese government program funding going directly to industry for research equipment and interest free loans, and on the many visitors returning from Japan reporting on the large manpower and activity on ceramics R&D at the many companies visited.

The table below summarizes the Japanese Ministry of International Trade and Industry (MITI) budget devoted to fine ceramics. The technology development programs are the fine ceramics research project (R&D of Basic Technologies for Future Industries or their "Jisedai") and the gas turbine component development project (Moonlight Project). Until recently this segment was the only funding information available, and was compared to the U.S. Government funded programs. Although it was known that the Japanese Government also funded industry directly through an equipment and loan program, funding levels were not previously disclosed. Government targeted technology areas are included in the program, and the loans are to be paid back for commercially successful projects. Besides MITI, ceramics research is also funded by the Ministry of Education (university research), Ministry of Transportation (diesel engines), and the Science and Technology Agency of Japan (aerospace research).

Japanese Government Funded Ceramics R&D

| | MITI Budget for New Materials<br>$ Millions ( 134 Yen/$) | |
|---|---|---|
| | 1987 | 1988 |
| Planning and Surveys | 0.3 | 1.0 |
| Technology Development Programs | 23.0 | 29.0 |
| Private Sector Capital Investment & Loan Service | 187.0 | 196.0 |
| Total MITI Budget | 210.3 | 226.0 |

A table of Federal Government funded R&D on structural ceramics technology is given below. The information was informally obtained from the responsible program managers as part of their coordination activities. The Vehicle Propulsion and Advanced Materials programs in the DOE Office of Transportation directly apply to automotive ceramics. The other programs are for basic research or other defense, aerospace, and large industrial applications. Much of the research is generic and we estimate about 30 percent is applicable to automotive heat engines. Not included are ceramics used for electronics, superconductors, military armor, and nuclear systems. Classified military programs are also not included.

## U.S. Government Funded Structural Ceramics R&D
## ( $ Millions )

| DEPARTMENT OF ENERGY | FY 1987 | FY 1988 | FY 1989 |
|---|---|---|---|
| CONSERVATION AND RENEWABLE ENERGY | | | |
| - Vehicle Propulsion | 12.0 | 12.0 | 13.5 |
| - Advanced Materials | 12.9 | 13.5 | 15.0 |
| - Industry Heat Exchangers | 1.9 | 1.8 | 2.3 |
| - ECUT Program | 2.8 | 2.9 | 0.6 |
| FOSSIL ENERGY | | | |
| -Advanced R&T Development | 2.0 | 2.5 | 2.7 |
| ENERGY RESEARCH | | | |
| - Basic Energy Science | 4.5 | 4.0 | 4.0 |
| NASA | | | |
| -Lewis Research Center | 6.2 | 7.5 | 7.5 |
| NATIONAL SCIENCE FOUNDATION | 3.7 | 3.0 | 3.2 |
| NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY | 2.4 | 3.0 | 3.0 |
| DEPARTMENT OF DEFENSE | | | |
| - Defense ARPA | 7.3 | 9.9 | 7.0 |
| - U.S. Air Force | 2.5 | 4.3 | 4.0 |
| - U.S. Army | 3.6 | 3.1 | 2.3 |
| - U.S. Navy | 1.9 | 2.4 | 2.3 |
| TOTAL | 63.7 | 69.9 | 67.4 |

The United States Advanced Ceramics Association (USACA) surveyed their members and found that private sector R&D expenditures totalled $152.9 million in 1986. Richard Alleigro, president of the USACA in 1987 said, " U.S. advanced ceramics companies believe in the long-term viability of this technology and their commitment to research and development bears this out." The results from the 23 companies surveyed are summarized in the following table, which also includes their Government funded R&D, subcontracted R&D to outside companies, and university grants. Advanced ceramics include electronic and structural ceramics.

## U.S. Private Sector Funded Advanced Ceramics R&D

## Survey of 23 USACA Member Companies

| | 1986 R&D Survey $ Millions ( % ) |
|---|---|
| Company Funded R&D | 152.9 (67) |
| Subcontracted R&D to Others | 19.2 (8) |
| University Grants & Contracts | 8.8 (4) |
| Government funded R&D at Companies | 46.4 (20) |
| Total Ceramics R&D | 227.3 (100) |

Question 4: What more needs to be done in the U.S.?

Answer: The Federal Government already has in place an aggressive program for development of ceramic technology. Within DOE both the Advanced Materials Development and the Vehicle Propulsion R&D programs in the Office of Transportation Systems are continuing, and technology developed under the programs is being transferred to industry. The program plans for these activities carry the work through FY 1993.

Industry has demonstrated a substantial commitment towards commercialization of ceramic technology. More and more industrial firms are becoming involved, greater internal resources are being used for facilities and R&D, and near-term commercialization applications are actively being pursued.

Question 5: Is this a high priority research effort from a budget standpoint in the Federal Government? If not, why not?

Answer: Development of ceramic technology is a high priority research effort from a budget standpoint in the Federal Government. In areas such as superconductivity, high speed aircraft, aerospace and space systems, and military armament ceramic technology is a key ingredient in program activities. Within DOE, the higher temperatures possible in energy conversion systems allowed by ceramic components and resulting in greatly improved efficiencies has established ceramic technology development as a high priority. For instance, during the FY 1989 appropriation hearings on the DOE Conservation budget ceramic technology development programs were specified as the number one priority. In the DOE Office of Transportation Systems budget for FY 1989, over 55 percent of the funding, approximately $30 million, is allocated to ceramic technology development activities.

**Question 6:** Please identify all ceramic research by the Federal Government, including its status.

**Answer:** The Department of Energy (DOE) does not have information on all of the ceramic research in the Federal Government, nor its status. The National Critical Materials Council (NCMC) in the Executive Office of the President has been asked to determine such information.

At DOE, the Energy Materials Coordination Committee (EMaCC) is responsible for coordination and exchange of programmatic information on ceramic technology development. Attachment F is a copy of the EMaCC Annual Report for 1987 containing information on all of the DOE materials programs and projects.

The Interagency Coordination Group on Structural Ceramics meets annually for Federal managers to exchange programmatic information, including current and planned future budgets. There is an annual report prepared with restricted distribution to the participating program managers.

Question 7: What are the expected technological advantages or benefits of ceramics for the consumer, safety, driveability and performance, and for energy conservation and emission control?

Answer: The technological advantages or benefits of ceramics have been summarized effectively in a Society of Automotive Engineers paper (SAE 881150) prepared by representatives of Eaton Corporation and GTE Corporation, two companies which have formed a consortium to manufacture and supply ceramic components to the automotive industry. The conclusions contained in the paper, titled "Ceramic Engine Components", are as follows:

1. Ceramic materials offer high temperature capabilities, wear resistance, controlled thermal conductivity, low thermal expansion, light weight, and increased stiffness over conventional materials.

2. Ceramics offer opportunities to operate engine valves at higher temperatures and with lower wear than the standard metals. These additional benefits will justify higher costs sufficiently to make the valves economically viable. Other valve train components made from these materials offer the potential to control lash and to increase the system stiffness while reducing weight, and lowering wear resulting in higher allowable operating speeds and better engine performance.

3. Ceramics can be prepared with a range of thermal conductivities, offering the potential to control heat transfer in a variety of components from exhaust port liner to cylinder head firedecks.

4. Ceramics have unique properties which with engine modification will allow new cost-effective solutions to long-standing design issues. Ceramic components are already in production in automobile and truck applications around the world. Some of these, and the properties which lend them utility, are 1) silicon nitride turbocharger rotors in the 1987 Buick GNX (low density, high temperature capability), 2) exhaust port liners in the Porsche 944 Turbo (insulation), and 3) rocker arm tips in selected Mitsubishi automobiles (wear resistance, low friction).

5. With the present level of fuel prices, and the requirements presented by emission regulations, current opportunities for ceramic components exist in engines which require high durability and dimensional control, and potential application in speciality high performance engines. The occurrence of a fuel shortage or dislocation will encourage effective use of high temperature components for fuel efficient turbocompound engines.

Question 8: It is my understanding that many of these technologies are already in use commercially in new motor vehicles and, of course, as new vehicles replace older vehicles they will provide some total fleet increase in energy efficiencies. That, of course, will take time. However, that table provides the contractor's estimates of those increases compared to a more conservative view by industry of those increases. The Subcommittee is concerned that the public is not getting a true picture from such studies about the actual potential for greater energy efficiency over a particular base year in the motor vehicle sector from a technology standpoint. I request your comments, particularly the DOE and DOT. In responding, please provide information on the status commercially of each of these technologies (i.e., when introduced in new vehicles in the U.S. and the percentage of new MY 1989 automobiles and light trucks using them). Please explain the percentage of fuel efficiency expected over a stated base year and MY 1989 from each technology when there is an expected fleet turnover and identify and provide the same information regarding future technologies not yet commercialized.

**Answer:** The Department of Energy studies fuel economy issues as part of its statutory responsibility to comment on Department of Transportation CAFE rulemakings, and to support its energy demand analysis work. In doing so, we have studied fuel economy technologies for automobiles and light trucks. This work has been conducted by DOE staff, DOE national laboratories, and contractors such as Energy and Environmental Analysis, Inc., which is cited in your letter.

Based on that work, we would judge the fuel efficiency gains quoted in your letter to be a reasonable set of estimates of what can be achieved using evolutionary and relatively near-term fuel economy technology, as well as new technology (such as ceramics for friction reduction) which is still in the development stage. The enclosed two reports "Analysis of the Capabilities of Domestic Auto-Manufacturers to Improve Corporate Average Fuel Economy", and "Light Duty Truck Fuel Economy" (Attachments G and H) describe our previous work in this area. We are updating these studies by examining more advanced fuel economy technologies, analyzing foreign manufacturers' capabilities and compiling an assessment of fuel economy potential to the year 2000.

In more specific response to the questions in your letter, the following information is provided:

- All of the technologies listed in the letter, with the sole exception of intake valve control, have been commercialized and are in use in vehicles currently sold in the United States. Some are more frequently used by foreign manufacturers (e.g., 4 valve per cylinder) and some by domestic manufacturers (e.g., 4-speed transmissions)

- The fuel economy potential of the technologies is also well established since they are in use today. However, the degree to which these technologies will affect future vehicle fleet fuel economy depends on:

  (a) The rate at which vehicle manufacturers adopt the available technology in their full product lines;

  (b) The mix of future vehicle types (the 4 valves per cylinder approach is not particularly useful in trucks with high torque requirements at low speeds) and sizes (4-speed automatics are more effective in larger cars); and

  (c) the degree to which vehicle manufacturers choose to exploit the technology for fuel economy gains instead of performance gains.

- This last point is important because it may explain differences in estimated fuel efficiency benefits for specific technologies. For example, foreign manufacturers have generally used 4 valves per cylinder to increase performance, replacing a similar size 2 valve/cylinder engine and substantially increasing performance. On the other hand, GM (the only domestic manufacturer to use the 4 valve/cylinder technology to date) has replaced a larger 6 cylinder, 2 valve/cylinder engine with a smaller, 4 cylinder 4 valve/cylinder engine and have shown fuel economy gains similar to those in the draft OTA report. Attachment I, an excerpt from DOE's recent comments to DOT on the 1989 CAFE rulemaking, contains an analysis of this point.

- **Attachment J, "The Fourteenth Periodical Report on the Motor Fuel Consumption Model" (MFC) contains a detailed projection of future fuel demand based on currently available information regarding manufacturers plans for introducing fuel economy technology.** This projection assumes future new car fuel economy will rise to about 30 mpg by 1995 based on the continuing adoption of fuel economy technology into new car design. Over time these improvements will work their way into the total fleet of vehicles and the total fleet fuel economy will rise to 30 mpg (EPA combined test value) by about the year 2000.

Question 9: What is the potential from a technology standpoint only to improve energy efficiency of the total automobile and light duty truck fleet over the next 20 years, taking into consideration your response to the previous sentence?

**Answer:** In the short-term, to 1995 and to some extent 2000, relatively well-known evolutionary technology will play a major role in the achievement of increased fuel efficiency. Some new technologies which are still in the development stage are also likely to be important for year 2000 new car fuel economy. Beyond 2000, the achievable fuel efficiency will depend more on advanced technology and alternative engines. The prognosis for the latter period is, of course, less certain.

We believe that conventional technologies standpoint (such as those technologies discussed in the answer to Question 8) are capable of raising new car fuel economy to between 35 and 40 mpg (EPA). This estimate assumes that the size mix of vehicles remains constant. For this level of MPG to be achieved, ongoing development work (both private and government) will have to continue to be pursued, and the then best available technology would have to be fully adopted in new vehicle design over the 1995 to 2000 period. Such a course would produce passenger car fuel economy in the 35 to 40 mpg range and light truck fuel economy in the 30 to 35 mpg range. We note that these available technologies would include, however, use of diesel engines in cars, and particularly, light trucks. Thus, we assume that the customer acceptance problems and emission problems of diesels will be overcome. By 2010, these fuel economy improvements will have largely worked their way into the fleet.

In the mid-term (2000 to 2010) the potential for high risk, long run light duty vehicle technologies such as ceramic parts, gas turbines, electric vehicles, and hybrid vehicles is quite hard to quantify. There is a very good chance that each of these technologies will experience some commercial success (even if only in niche markets) within the next 20 years. Their initial success may be as much due to concerns about the environment as to the efficiency and fuel substitution potential they offer.

The Office of Transportation Systems conducted an informal delphi study during 1988 in which 58 respondents from a broad spectrum of automotive experts replied. The penetration of these technologies in the year 2010 was very dependent upon the assumed future price of gasoline. The penetrations of new technologies in 2010 which were expected by the median response for the two price scenarios are shown in the following table:

Penetration of Advanced Technologies in the Total 2010 Auto Fleet

| | Real Price of Gasoline (88 $) | |
|---|---|---|
| | $1.50 | $3.00 |
| Ceramics that Save 5% of Fuel | 10% | 15% |
| Gas Turbine | .1% | 2% |

This simple delphi projection does not represent what will happen, but it does reflect the judgment of dozens of experts from diverse backgrounds, most of whom have no association with any of the R&D being done on these technology programs.

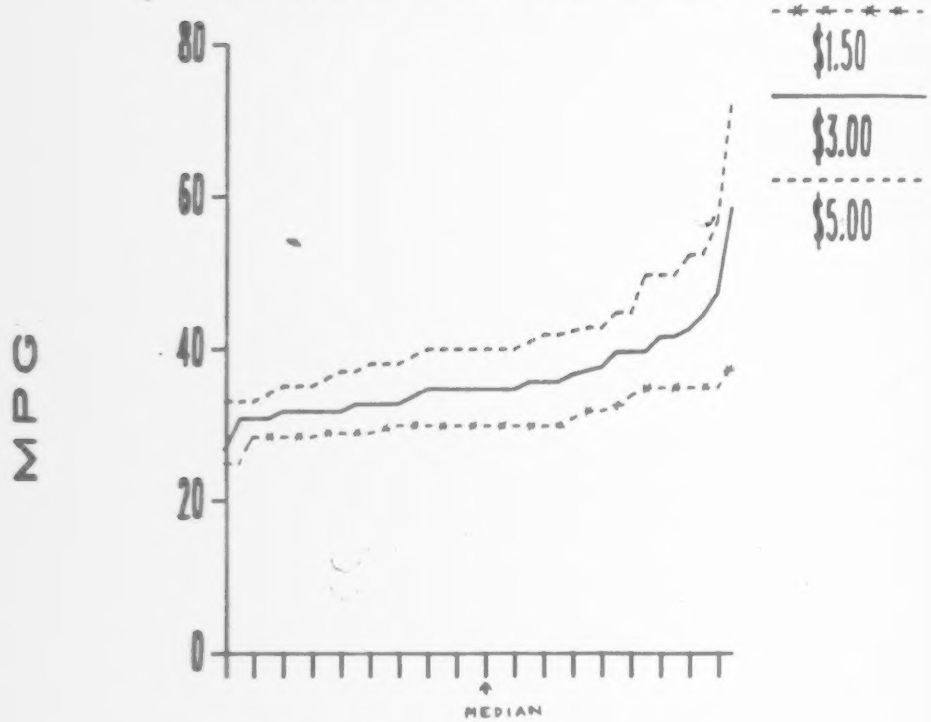
The penetration numbers may appear to be quite small. But as a result of the tremendous size of the highway sector and its great amount of annual fuel use, even small penetrations bring about large absolute oil savings. For example, 2 percent penetration by gas turbines in autos in 2010 for the $3 scenario results in 3.2 million gas turbine autos in operation that save .5 billion gallons of gasoline, assuming that the gas turbine achieves its goal of a 30 percent improvement in fuel economy. This would be a saving of $1.5 billion in fuel bills to the owners of these vehicles (at the $3 per gallon projection of fuel prices). Of course, larger penetrations in subsequent years would result in even larger oil and dollar savings.

Even in the $1.50 price scenario, ceramics are expected to have significant penetrations by the delphi respondents. The median penetration of 10 percent for autos and 5 percent for light trucks would bring forth gasoline savings of about .5 billion gallons which would be valued at $.75 billion with a price of $1.50 per gallon.

The penetration of 10% by ceramics in the $1.50 scenario is identical to the penetration rate that Argonne National Laboratory found in their delphi study that involved a completely different set of experts.

The OTS delphi exercise also asked the respondents to estimate the year 2010 new car fuel economy (under free-market conditions) for three different gasoline price scenarios. At $1.50 the new car mpg was estimated to be 30. At $3.00 it was estimated to be 35 mpg. And at $5.00 it was estimated to be 40 mpg. These figures were the median values of the responses. The attached figure shows the distribution of mpg values by the respondents for the three price scenarios. Very few of the respondents expected over 40 mpg, except in the $5 a gallon case where 50 percent expected a value of 40 mpg or above.

# YEAR 2010 NEW CAR MPG
## RELATED TO GAS PRICE



OTS DELPHI RESPONDENTS

**Question 10:** Please also discuss the problems or limitations and risks regarding the commercialization of such technologies. What are the promises and uncertainties of such technologies?

**Answer:** In general, there is a modest risk associated with those technologies that are already commercialized. This risk is not technical as much as market-related. Even if a technology is fully adopted in one market segment it may not be accepted by consumers or be economic in another market segment.

While most fuel economy technologies have been readily accepted by consumers there is always a possibility that consumers will find some technology unacceptable. The diesel engine is a good example of where the technology was fully commercialized in one market (heavy duty trucks) but had difficulty in another market (cars) and all but disappeared from that market.

For uncommercialized technologies, risks and uncertainties are substantially greater. Technologies in this category include:

- ceramic materials for friction reduction
- lightweight composite materials for body parts;
- stop/start electric transmissions,
- direct injected diesel engines for light duty vehicles; and
- variable area ceramic turbochargers.

Most of these technologies have been used in various applications and in alternative configurations. Commercializing these technologies in the light duty vehicle market will depend on continuing research and development efforts by manufacturers and others, technical success in engineering application efforts, cost reductions, achieving environmental and safety goals and consumer acceptance. Thus, the market risk is compounded by technical uncertainties.

Question 11: What is the likelihood of expanding significantly use of diesel engines in the U.S., taking into consideration emission problems?

**Answer:** Expanded use of diesel engines in light duty vehicles is technically possible. Engines and emission control systems can be, and have been, designed to achieve low emission levels. However, the design changes required (e.g., sophisticated electronic fuel injection systems or particulate traps) will likely raise the cost of what is already a more expensive engine.

Under current fuel prices this makes the diesel engine uneconomic in private cars and light trucks. Unless fuel prices increase significantly or other factors intervene, substantial penetration of diesel engines is not anticipated. We expect that diesel engine use in light duty vehicles will increase only slightly, if at all, in the 1990's.

As indicated in answer to Question 9, achieving total fleet fuel economy in the 35 to 40 mpg range by 2010 would require expanded diesel engine use, particularly in light trucks.

Question 12: Would greater use of 5-speed transmissions over automatic transmissions improve fuel efficiency? I understood that both manual and automatic transmissions are now almost equally efficient.

**Answer**: Manual and automatic transmissions provide nearly the same driveline efficiency in larger vehicles where the more advanced automatic transmission designs (4-speed, overdrive, lock-up torque converter) are used. Greater use of manual transmissions would provide no significant benefit in these vehicles.

However, in the smaller cars (subcompacts, minicompacts) automatic transmissions are less efficient (because of the relatively larger torque converter losses). Greater use of 5-speed manual transmissions, or the introduction of continuously variable transmissions (as has occurred in one 1989 model year import) would improve fuel efficiency.

Question 13: What economic or other factors can reasonably be expected to influence further energy efficiency gains between now and the year 2000? What factors could affect achievement of a standard of 35 miles per gallon that some argue should be a new standard by law? What is the realistic likelihood of significantly increasing motor vehicle fuel efficiency of new vehicles above the efficiencies achieved for MY 1987 new cars and trucks?

**Answer**: Three major factors will influence passenger car and light truck fuel economy between now and the year 2000:

1. the existence or development of cost-effective fuel economy technology that is both environmentally benign and acceptable to consumers,
2. the price of motor fuels, and
3. government policy.

Although there is considerable uncertainty about future motor fuel prices and fuel efficiency policy, DOE continuously studies the technological potential for improvement in automobile and light truck fuel economy. Technology already in use in some makes and models, if more widely adopted, could cost-effectively improve new car fuel economy to the 30 miles per gallon range. Higher fuel prices could also lead to improvements above 1987 levels. Technologically, significantly higher fuel economy is feasible, but its realization is dependent on the economics of fuel, on consumer preferences, and on government policy.

Question 14: The Office of Technology Assessment in recent discussions with our staff has indicated that combining autos and light trucks into a "light duty fleet" for fuel consumption and fuel economy is an accepted practice for analysis purposes, as illustrated by recent reports by DOE's Oak Ridge laboratory which apparently were not published because of budget reasons. That combination, [cars and light trucks] however, is not recognized in setting fuel economy standards by law. Also, cars and trucks are designed for different purposes. I request those reports and your comments on combining such fleets when discussing fuel economy of the past, present or the future.

Answer: There was a funding constraint that prevented the Oak Ridge National Laboratory from publishing the 1987 edition of the MPG report. This constraint was overcome in 1988 and the report was published in August 1988 (although copies were not printed and distributed until November). Attachment K, "Light Duty Vehicle MPG and Market Shares Report: First Six Months of Model Year 1988" ORNL-6496 is a copy of this most recent report.. The ORNL MPG report does combine autos and light trucks in a "light duty vehice" (LDV) classification. For example on page 4-2 of this report the sales, market shares, and mpg values are shown for the 1976-1988 period. The LDV mpg grew from 16.8 to 25.6 over this period. If the 1988 shares for cars and light trucks reverted to the 1976 shares (an auto share change from 68.5% to 80.2%) and the 1988 fuel economies remained the same, the 1988 LVD mpg would have been 1.0 mpg higher, or 26.6 mpg. Therefore the fuel economy impact of the shift toward more light trucks during that period was about a one mile-per-gallon decline in all light duty vehicles.

DOE has found it very useful to combine autos and light trucks when discussing fuel economy because most of both types of vehicles are purchased by households and are used by households for pretty much the same purposes. In fact, passenger vans are used 90% of the time for the same purposes as autos. Station wagons (which are classified as autos) are used for the same purposes as autos 88% of the time. Even pickups are used like autos 84% of the time. These results were obtained from the 1983-84 Nationwide Personal Transportation Study conducted by DOT. One cannot fully understand the changing mix of cars by size class over the past 13 years without understanding the growing share of sales accounted for by various light truck classes.

We analyze the future fuel economy capability for cars and light trucks separately (as indicated in Attachments G and H). In fact, we analyze the fuel economy capabilities of automobiles in several size classes which reflect the unequal cost and performance benefits of fuel economy technologies in different types of cars. Likewise, fuel economy technologies will have unequal costs and benefits in cars and light trucks especilly considering the more severe load and use requirements for which light trucks are designed.

If cars and light trucks were combined for fuel economy standards purposes, the analysis of appropriate fuel economy levels would still have to be carried out separately for the two fleets and then combined based on an assumed sales mix. This would only introduce greater uncertainty for the government in setting the standards and for the manufacturers in meeting the standards.

Question 15: Enclosed also are two letters from foreign auto makers about their experimental vehicles. Some in the energy conservation community have cited those vehicles as evidence that the U.S. auto makers and foreign auto makers are capable now of improving their fuel economy significantly over the long term. The letters would appear to raise serious doubts about that capability. Neither vehicle is in the production stage or stated to be so at any time. I request your comments. Do you view these prototypes of evidence that foreign and domestic auto makers could reasonably produce and sell vehicles of this type in the relatively near future?

Answer: These vehicles are evidence of what fuel economy levels can be achieved in experimental cars of these sizes, if maximum use is made of existing technology. They are not indicators that such vehicles could be produced at competitive costs or that manufacturers could sell large numbers of them if they were produced. We note that foreign automakers' fuel economy prototypes are uniformly lightweights, low power, four or fewer passenger, almost all with diesel engines and manual transmissions. Thus, they represent a very small segment of the range of vehicle characteristics represented in today's vehicle market. The Department of Energy is giving special attention to these prototype vehicles in its ongoing analysis of foreign manufacturers fuel economy capabilities.

Prototype vehicles play an important role in the manufacturers' fuel economy technology development process. They provide a vehicle test bed on which different components and concepts can be tried, synergistic effects examined, and fuel economy and performance impacts measured. These vehicles are also important for fuel economy analysis purposes because they help define the technological boundary for fuel economy. In these contexts, they are relevant to the debate about what future fuel economy levels are appropriate. However they are not, in and of themselves, a good measure of what future fleet fuel economy can or should be. These vehicles normally are not restrained by either environmental or safety regulations.

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Subcommittee on Oversight and Investigations
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December 8, 1988

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Dear Secretaries Herrington and Burnley, and Administrator Thomas:

Enclosed is a recent Automotive News article regarding the development and commercialization of ceramics for motor vehicle use. It states:

> The technology to develop heat-resistant, lightweight car components made of ceramics already exists. But there is a gap of more than 10 years between research and development and the commercialization of ceramics products, Wallace said. The major obstacle is economic -- Wallace said there are no incentives to accelerate the use of ceramics or to invest more money in research.
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> * * * * * * * * * * *
>
> The use of ceramics could also slow the loss of engine heat and improve engine output and efficiency; typically as much as 25 percent of an engine's heat is lost thought the walls, Wallace said.

> But there are still major problems to using ceramics in a car engine, he said. The most difficult to solve is the inherent brittleness of the substance, which is intensified when stress is applied to one area.
>
> He said the answer may lie in the development of tougher ceramics, including ceramic composites.

The article states that "we are still competitive with Japan," but that "Japan is clearly ahead of the United States in automotive use of ceramics...because development of the ceramics industry has become a Japanese national priority." I am concerned about that comment and request that each of you explain the "priority" given by the U.S. government and industry since 1980 to the development and commercialization of ceramics in the U.S. Are we still competitive? What is the status of ceramic development and commercialization in Japan, the U.S. and elsewhere? What is the extent of the research effort in the U.S. and Japan in dollars by government and the private sector? What more needs to be done in the U.S.? Is this a high priority research effort from a budget standpoint in the Federal Government? If not, why not? Please identify all ceramic research by the Federal Government, including its status. What are the expected technological advantages or benefits of ceramics for the consumer, safety, driveability and performance, and for energy conservation and emission control?

The following is a table of reported efficiency improvements for developed or near-term technology which, I understand, stems primarily from an August 1988 contract report for the Office of Technology Assessment:

| Technology | Percentage Improvement Over 1987 Base | |
|---|---|---|
| | EEA[1] | Industry[2] |
| Engine Improvements | | |
| 4 valve per cylinder | 10.0 | 4-5 or less |
| Overhead camshaft | 6.0 | low |
| Roller cam followers | 1.5 | 0.5 - 4.0 |
| Low friction rings/pistons | 2.0 | |
| Throttle body fuel injection | 3.0 | 0 - 3 |
| Multipoint fuel injection | 6.0 | 4 |
| Intake valve control | 4.0 | 1 - 2 |
| Four speed automatic transmission | 7.5 | 5 - 6 |
| Electronic transmission control | 1.5 | low |
| Aerodynamics, $C_D = 0.34$ | 3.4 | 3 |
| Tire improvements | 0.5 | |
| Lubricants (5W-30) | 0.5 | |
| High efficiency accessories | 1.0 | |

Notes: 1. Energy and Environmental Analysis, Inc., Developments in the Fuel Economy of Light-Duty Highway Vehicles, draft contract report to OTA, August, 1988.

2. Based on comments received in review of the EEA draft report and at an OTA workshop on automotive fuel economy, September 14, 1988.

It is my understanding that many of these technologies are already in use commercially in new motor vehicles and, of course, as new vehicles replace older vehicles they will provide some total fleet increase in energy efficiencies. That, of course, will take time. However, the table provides the contractor's estimates of those increases compared to a more conservative view by industry of those increases. The Subcommittee is concerned that the public is not getting a true picture from such studies about the actual potential for greater energy efficiency over a particular base year in the motor vehicle sector from a technology standpoint. I request your comments, particularly the DOE and DOT. In responding, please provide information on the status commercially of each of these technologies (i.e. when introduced in new vehicles in the U.S. and the percentage of new MY 1989 automobiles and light trucks using them). Please explain the percentage of fuel efficiency expected over a stated base year and MY 1989 from each technology when there is an expected fleet turnover and identify and provide the same information regarding future technologies not yet commercialized. What is the potential from a technology standpoint only to improve energy efficiency of the total automobile and light duty truck fleet over the next 20 years, taking into consideration your response to the previous sentence? Please also discuss the problems or limitations and risks regarding the commercialization of such technologies. What are the promises and uncertainties of such technologies? What is the likelihood of expanding significantly use of diesel engines in the U.S., taking into consideration emission problems? Would greater use of 5-speed transmissions over automatic transmissions improve fuel efficiency? I understood that both manual and automatic transmissions are now almost equally efficient. In responding to these matters, please state any assumptions. Also, please comment on the table.

What economic or other factors can reasonably be expected to influence further energy efficiency gains between now and the year 2000? What factors could affect achievement of a standard of 35 miles per gallon that some argue should be a new standard by law?

What is the realistic likelihood of significantly increasing motor vehicle fuel efficiency of new vehicles above the efficiencies achieved for MY 1987 new cars and trucks?

Some years ago the Department of Transportation established the Research Safety Vehicle program. What are the status and results of that program? To what extent has it helped improve safety in smaller, more fuel efficient vehicles? What are your views on the potential efficiency of smaller vehicles, the likelihood of increasing market share of such vehicles, the effects of such increases on competition and safety, and other relevant considerations?

The Office of Technology Assessment in recent discussions with our staff has indicated that combining autos and light trucks into a "light duty fleet" for fuel consumption and fuel economy is an accepted practice for analysis purposes, as illustrated by recent reports by DOE's Oak Ridge laboratory which apparently were not published because of budget reasons. That combination, however, is not recognized in setting fuel economy standards by law. Also, cars and trucks are designed for different purposes. I request those reports and your comments on combining such fleets when discussing fuel economy of the past, present or the future.

Enclosed also are two letters from foreign auto makers about their experimental vehicles. Some in the energy conservation community have cited those vehicles as evidence that the U.S. automakers and foreign automakers are capable now of improving their fuel economy significantly over the long term. The letters would appear to raise serious doubts about that capability. Neither vehicle is in the production stage or stated to be so at any time. I request your comments. Do you view these prototypes of evidence that foreign and domestic automakers could reasonably produce and sell vehicles of this type in the relatively near future?

I observe also that on November 22, 1988 the EPA wrote to NHTSA concerning the Corporate Average Fuel Economy standard for model year 1990 passenger cars from the standpoint of its "early stages" global warming program. EPA agrees that "one model year will not have a significant effect on global warming." EPA provides no supporting data or analysis for this statement. However, EPA states that as the U.S. and the world "improve our understanding of the global warming phenomenon, it is likely that an increase in vehicle fuel efficiency will be necessary to reduce emissions of greenhouse gases." I am not certain why EPA aimed its comments only at passenger cars, as there are significant sources of gases worldwide and in the U.S. beyond passenger cars. However, I agree that this must be a concern. EPA concludes by saying:

> NHTSA and EPA need to work together closely to decide upon an appropriate strategy for assuring that future vehicles reduce the emissions of such gases.

I applaud that idea of NHTSA and EPA working "together closely." You will recall that last year this Subcommittee strongly indicated the need for that and last June a memorandum of understanding was signed by the two agencies. That provides the mechanism for working together. However, that is a "two-way street." Regulations under development at EPA and promulgated have also been reported to have impacted on fuel economy in an adverse way and may even have contributed to the problems faced by the manufacturers today in achieving improved fuel economy. That does not, of course, help the greenhouse problem.

I believe that the EPA suggestion is sound and I urge that the memorandum of understanding be promptly examined to see if changes are needed to ensure such two-way coordination in addition to safety. I request the results of that examination.

Additionally, to what extent have Europeans and Japanese manufacturers in selling cars and trucks in the U.S. improved or worsened their corporate fuel economy since MY 1981 as compared to U.S. manufacturers? Please explain. What was their corporate average for MY 1981 and MY 1987 compared to U.S. firms for those years?

Finally, I understand that in the not too distant future the Federal Aid Highway Program will be examined and possibly modified. It seems that should afford a great opportunity for each of you and Congress to address the issues of fuel economy and, just as importantly, ozone, carbon monoxide, and greenhouse gas pollution. What are your plans in this regard?

I request your response within your areas of expertise to the above matters within your expertise within 45 days after receipt of this letter.

With best wishes.

Sincerely,

John D Dingell

JOHN D. DINGELL
Chairman
Subcommittee on
Oversight and Investigations

Enclosure

cc: The Honorable Thomas J. Bliley, Jr., Ranking Minority Member
Subcommittee on Oversight and Investigations

The Honorable Diane K. Steed, Administrator
National Highway Traffic Safety Administration
Department of Transportation

The Honorable Robert E. Farris, Administrator
Federal Highway Administration
Department of Transportation

Dr. John H. Gibbons, Director
Office of Technology Assessment

The Honorable Charles A. Bowsher, Comptroller General
General Accounting Office

Senator METZENBAUM. I notice that Senator Conrad has joined us. Senator Conrad, do you have an opening statement that you care to make?

Senator CONRAD. Mr. Chairman, I do not, and I will forgo any questioning given the number of witnesses that we have before us this morning.

Senator METZENBAUM. Senator Wirth, do you have any questions?

Senator WIRTH. Yes, I do, Mr. Chairman.

First of all, I want to thank EPA for being out front on this. You seem to welcome change, and I thank you very much. Many of us appreciate what you and Mr. Reilly and company are doing.

I focus this, first of all, to you, Secretary Berg. On page 5 of your testimony you say that higher fuel efficiency can be part of a national strategy. Should it be part of a national strategy?

Dr. BERG. This probably will be part of the national strategy. There is no question that this is one of the factors that will be in the national policy. Yes, sir.

Senator WIRTH. It should be. In other words, we should have higher—is that the position——

Dr. BERG. We should have increased conservation and fuel efficiency, yes, sir.

Senator WIRTH. We should have higher—it is the position of the Department of Transportation that we should have higher fuel efficiency standards. Is that correct?

Dr. BERG. It is our position, depending upon other economic factors and environmental factors——

Senator WIRTH. Let me ask you this. Yes or no. Is it the position of the Department of Energy that there should be higher fuel efficiency standards? Yes or no.

Dr. BERG. Caveated, yes.

Senator WIRTH. The answer is yes.

Last year the Department said that we shouldn't relax the CAFE standard. You did not say that in your testimony. Do you have the same position you had last year?

Dr. BERG. Until we have gotten the final rule from the Department of Transportation, we're not prepared to take a position today.

Senator WIRTH. Before a final rule was made last year, you said to the Department of Transportation they shouldn't relax standards. And yet, has the Department of Energy changed since last year?

Dr. BERG. Again, sir, until all of the people that are in position are in place, we do not want to make any positions that would be either felt that they were too much or too little.

Senator WIRTH. I'm sure you really believe that, Secretary Berg, but we'll come back to that. Okay? [Laughter.]

Senator WIRTH. If I might talk to the Department of Transportation and Mr. Smolkin. You talk on page 1 about pending rulemaking concerning whether to reduce the corporate fuel economy standard. Right?

Mr. SMOLKIN. That is right, sir.

Senator WIRTH. What about improving the standard? Have you focused on that at all, about improving the standard rather than reducing the standard? Or is the only option at the Department of Transportation to reduce the standard?

Mr. SMOLKIN. The only option in the ongoing rulemaking would be to set a standard between 26.5 and 27.5.

Senator WIRTH. Why are we talking about the only option being to reduce rather than to improve fuel efficiency?

Mr. SMOLKIN. The reason for that, sir, is that we have issued a preliminary notice indicating——

Senator WIRTH. When did you issue that?

Mr. SMOLKIN. Last August.

Senator WIRTH. And so, even though the Department of Energy has said that they aren't going to make any policy recommendations until new people are in town, you are just going to go along with what the old people did at the Department of Transportation? Is consistency not the mother's milk of this administration? Tell me what the situation is? Why, if they're not making a decision until new people are in town, have you made a decision that the only option is to reduce?

Mr. SMOLKIN. Well, we have a statutory obligation to carry out——

Senator WIRTH. You can withdraw that draft rulemaking any time you want, can't you?

Mr. SMOLKIN. We, in fact, can do that, and that would be one of the factors that we could consider in deciding whether to set a limit between 26.5 and 27.5; the latter is, in fact, the statutory limit.

Senator WIRTH. But could you withdraw that rulemaking and put a new one out that said that one of the options to be considered would be to increase fuel efficiency standards?

Mr. FELRICE. If I can, Senator Wirth. The current rulemaking before the Department is only for model year 1990. And the previous administration proposed to possibly lower that standard. The Secretary certainly has the option now of terminating that rulemaking, withdrawing the notice, as you said, and he is considering that.

Senator WIRTH. We would strongly recommend that you do that. I think that probably makes a lot of sense, don't you think? I don't think there are very many people who truly believe that a reduction is what George Bush, the environmentalist, would want us to do, do you think? [Laughter.]

Mr. FELRICE. Well, that is being discussed within the administration.

Senator WIRTH. Let me ask you a second question, if I might. I've got a limited amount of time. We can come back to this, if we might.

On the top of page 2, Mr. Smolkin, you list a whole variety of factors. What is the most important of those?

Mr. SMOLKIN. The Congress in setting up the fuel economy——

Senator WIRTH. Do you have any priorities? Do you all have any priorities?

Mr. SMOLKIN. We balance those factors.

Senator WIRTH. What are your priorities? I mean, comfort, passenger carrying capacity? What are the priorities?

Mr. **Felrice**. There are four statutory criteria, Senator Wirth: technological feasibility, economic practicability, the need of the Nation to conserve energy and the effect of other Federal standards on fuel efficiency. The act does not guide the Department in weighting those.

Senator **Wirth**. Is there a statutory piece that talks about comfort and passenger carrying capacity?

Mr. **Felrice**. That comes into the economic practicability criterion.

Senator **Wirth**. Is that in the statute or is that from the Department of Transportation?

Mr. **Felrice**. That has been the Department's interpretation of the statute and has been supported in the courts.

Senator **Wirth**. Now, is it the case that it is important that interior space is what you mean by comfort and passenger carrying capacity?

Mr. **Felrice**. That would be part of that criterion.

Senator **Wirth**. And is there a direct correlation between fuel efficiency and passenger carrying capacity?

Mr. **Felrice**. There doesn't have to be, no, because interior volume has essentially remained constant over the last 10 years——

Senator **Wirth**. It has remained the same, hasn't it?

Mr. **Felrice** [continuing]. While fuel efficiency has increased.

Senator **Wirth**. But it is still one of your criteria. The reason I'm bringing this up is that this is one of the straw men that gets thrown up. And you are familiar with that I know. But every time we talk about fuel efficiency, we get these scare memos from the automobile manufacturers who say if you go to fuel efficiency, everybody is going to be driving around in things that are smaller than old post-World War II Volkswagen.

And the reason that I bring that up is to point out that, in fact, as you are very accurately pointing out, interior space has remained constant since the late 1970s even though fuel efficiency has gone up very significantly.

Mr. **Felrice**. That's correct.

So, it's a little bit—I just wanted to put that in there. I don't understand why passenger carrying capacity is one of the criteria that you all continue to use because maybe that reflects what Detroit wants you to put in there, but I am curious about that. That doesn't make sense anymore, does it?

Mr. **Felrice**. Well, drastic increases in fuel efficiency might result in much lower interior volumes than currently exist. I think fuel efficiencies for the fleet on the order of 50 to 60 miles a gallon could probably not be attained while maintaining interior volume at the level it is now. We would probably see many more two-seater and four-seater cars.

Senator **Wirth**. Let me ask you about the technological capability, to follow up on Senator Metzenbaum's question. Technologically, are we capable of going significantly above the 27½ miles per gallon that we now have without major changes, without dramatic shudders in the industry?

Mr. Felrice. I would agree with my colleagues that some improvement in fuel efficiency, looking solely at technological feasibility, is possible. I'm not sure what you mean——

Senator Wirth. How much is some improvement do you think?

Mr. Felrice. Well, we have heard some comments here in the neighborhood of 32, 33, 35 miles a gallon.

Senator Wirth. So, it can be done. The Department of Transportation is testifying to us today, Mr. Chairman, that we can go up to 35. Is that right?

Mr. Felrice. I believe I prefaced my remark by just looking at technological feasibility. The statute does not permit us to only look at technological feasibility to the exclusion of the other statutory criteria.

Senator Wirth. Has the administration changed its view from then Secretary Kirkpatrick's statement and the new one that has recently been made about capability? She said that conventional technologies implemented in the 1995 to 2000 time period "are capable of raising new car fuel efficiency economy between 35 and 40 miles per gallon." That was her statement. She was in the old administration and is going to be in the new administration. Now, there is a consistency there. Is that still the position of the administration, that you can do that technologically?

Well, we're going to get the automobile companies in the next panel, and they're going to come up and tell us that technologically they can't do that. And obviously, what I want you all to do is to say, yes, they can do it which you have said and Secretary Kirkpatrick has said and others have said. Are you going to say that today, or are you going to duck?

Mr. Felrice. That was the Department of Energy's comment, not the Department of Transportation.

Senator Wirth. What is your position on that? Do you agree with Secretary Kirkpatrick?

Mr. Felrice. We don't have a formal position on that issue. I wish we did, but the new administration has not——

Senator Wirth. Did the old administration have a position on that that you could do it technologically?

Mr. Felrice. No, I don't believe Secretary Burnley ever said that.

Senator Metzenbaum. Do you personally believe it can be done?

Mr. Felrice. Again, I believe that some improvement probably to the low 30s is technologically feasible. But again, the other statutory criteria tend to lower that.

Senator Metzenbaum. We write the statutes. We could change the statute if you think that is necessary. That is not so big a problem. [Laughter.]

So, if you would tell us that is what we should be doing, we would be glad to accommodate.

Mr. Felrice. Well, I think the Congress was very wise in enacting the four criteria in the original statute because there is a balancing that has to be done.

Senator Wirth. When you did the ruling last year, didn't the statute require you to examine the technological feasibility? And you are saying the Burnley had no position, so therefore you didn't follow the statute and examine the technological feasibility last year?

Mr. **Felrice**. No. We examined the technological feasibility for model year 1989.

Senator **Wirth**. What did you find out last year?

Mr. **Felrice**. We found out that the manufacturers had attempted to achieve the statutory level of 27 and a half and they had invested in new technology, but that technology was counteracted by consumer demand for larger, higher performing cars.

Senator **Wirth**. What did you find out about the technology? That's the question, not the politics. The question relates to technology. What did you find out last year in terms of your statutory requirement to examine the technological capability? Did you find out in terms of the technological capability last year that you could increase above 27½ miles per gallon?

Mr. **Felrice**. That rulemaking did not address that issue, Senator. It only looked at whether the——

Senator **Wirth**. But you had to look at the technological capability in order to go through the rulemaking.

Mr. **Felrice**. But only for model year 1989.

Senator **Wirth**. All right.

Let me ask you this. Was your statement delivered today, Secretary Berg, the same as drafted in the Department, or was it changed by OMB?

Dr. **Berg**. As you are well aware, these things go through a whole draft procedure. There were some slight changes made by OMB.

Senator **Wirth**. What kind of changes did OMB make in your statement?

Dr. **Berg**. They asked that we reduce the amount of testimony.

Senator **Wirth**. What substance did the OMB take out of it?

Dr. **Berg**. The only substance that they reduced was going into the whole bit on figures. The figures that we reported here are the figures, but they asked that we reduce the amount that we say about them.

Senator **Wirth**. You mean there was no statement initially from the Department of Energy about having stronger fuel efficiency standards in your original draft?

Dr. **Berg**. No, sir, there wasn't.

Senator **Wirth**. How about you, Mr. Smolkin? Did you all have any changes made by OMB?

Mr. **Smolkin**. There were minor, technical changes, sir. The substance did not change at all.

Senator **Wirth**. I am glad to hear that in any case, that the administration didn't change it. But I am also, Mr. Chairman, surprised that there has been absolutely no administration position on this. They say, well, we're new in town. You wonder where everybody has been for the last eight years. It is not as if this is a new issue, as you all know. You've been around, Secretary Berg, for a long time I know, and so have you all been around for a long time. All the capability is there. All the analysis has been there, and yet we seem to have an administration adrift on this issue just like the Exxon Valdez was adrift, Mr. Chairman. I hope that we don't go up on the shoals like that particular tanker did, and I hope that you all are able to get a focus and get a direction and get somebody who is competent at the helm to get us in the right kind of a direction.

Thank you, Mr. Chairman.

Senator METZENBAUM. Thank you, Senator Wirth.

We're happy to have Senator Nickles who is the ranking member of this subcommittee with us and former chairman. I don't know if you have an opening statement or not, Senator, or whether you have any questions.

Senator NICKLES. Well, Mr. Chairman, thank you. And I want to thank you for having this hearing. I did request it and I appreciate your doing it. I apologize to the witnesses for missing part of their opening statements. As many of our colleagues, I think I have four meetings today that started at 9:30. So, there is a lot of activity when the Senate has returned. President Mubarak is in town, as many people are aware of, and meeting with a lot of Senators. But I do appreciate the hearing. I also appreciate the witnesses' statements.

Mr. Chairman, I have a lengthy statement. I will ask your permission to insert it in the record.

Senator METZENBAUM. Without objection.

Senator NICKLES. I might ask our three panelists in summary, all of you, we would like to see fuel efficiency. Certainly I would as well. Is that agreed upon? Everyone would like to see fuel efficiency increased.

There is some question of whether or not it should be done by federally mandated standards. Is that correct? Has anyone on the panel come out in favor of increasing mandated congressional standards today?

[No response.]

Senator NICKLES. Correct me if I'm wrong. Secretary Berg, is——

Dr. BERG. No, sir, we have not proposed that.

Senator NICKLES. But you would like to see fuel efficiency increase.

Dr. BERG. We'd like to see fuel efficiency. As we stated, we are looking at what, if any, legislative things could be done, but we are certainly not at this point in a position to recommend these things because we are looking at a balance, a balance of energy efficiency, a balance of domestic supply and alternative fuels and uses that could all work to mitigate the amount of transportation fuel being used at the present time.

Senator NICKLES. So, you do want to see efficiency increased. It just a question of whether or not you would do that by federally mandated standards or not that would impose large penalties on manufacturers and consumers if those standards are not met. Is that correct?

Dr. BERG. That's correct.

Senator NICKLES. Well, I appreciate that.

And you are now in the process of reviewing the request on the 1990 models, and that decision will be made when?

Dr. BERG. We haven't received the final rule yet from the Department of Transportation. At the time that we receive it, then we will do the technological and the energy impacts for the 1990——

Senator NICKLES. So, is that going to be done within a month or two or three?

Dr. BERG. I would have to defer when that—let's see. Did you give us a date?

Senator NICKLES. Mr. Smolkin, can you tell us?

Mr. SMOLKIN. We anticipate a decision on that this month, Senator.

Senator NICKLES. So, you are receiving input from interested parties and hopefully knowledgeable parties as far as what impacts it would have?

Mr. SMOLKIN. We have received such comments, and we are reviewing the comments now.

Senator NICKLES. And when you talk about a balance, Mr. Berg, you are talking about certainly the desire for increased efficiency, but also the balance of what it would mean to manufacturers, whether or not—particularly I would say domestic versus imports. You are talking about the impact on consumers.

When you talk about the scientific capability or the technological capability of the industry, my guess is you could probably come up or Congress could pass a law that says, well, we're going to make it 50 by the year 1995. And maybe we would all end up driving Moped bicycles or something, but they might be able to achieve 50, if Congress so desired. There might be some expense to public convenience and the loss of an automobile industry, but we could maintain that standard if Congress passed it, couldn't we?

Dr. BERG. You could, but I would suspect that the consumer out there might be writing a few letters about it, though, too.

Senator NICKLES. Well, so that's the balance that you're talking about.

Dr. BERG. Yes, sir.

Senator NICKLES. We could save a lot of lives if we passed a law that would outlaw automobile traffic. That would save a lot lives. What? Fifty thousand lives per year if Congress came up with that very high standard.

Dr. BERG. Yes, sir. And I would point out you might save more lives if you outlawed the Moped and the motorcycle too. [Laughter.]

Senator NICKLES. It's kind of a question of how to balance the variety of things that are involved here. And I guess I hear the summation of the panelist, Mr. Chairman—correct me if I'm wrong—but they all want to see fuel efficiency increased, but they are uncertain or at least they haven't received the guidance from the administration yet as far as the position on whether or not CAFE standards themselves should be increased. Is that correct?

Senator METZENBAUM. I'm not sure. As I understand Mr. Berg's response to Senator Wirth, it was that the Department of Energy feels with a caveat that we should raise the CAFE standards.

Dr. BERG. My answer, sir, if I may go back——

Senator METZENBAUM. Sure.

Dr. BERG [continuing]. Because I hope that I did not leave the wrong impression, is that is one option that we are looking at. We are not at this point in the position to recommend that at this point until we have given all the details to the study.

Senator METZENBAUM. At this point you do think it could be done.

Dr. **Berg**. This could be done, but at what cost. And we haven't gone through all the drills yet on what the cost would be.

Senator **Nickles**. So, you are not yet taking the position of increasing CAFE—you are not making the recommendation yet that increasing CAFE standards would be part of "the energy policy".

Dr. **Berg**. Not at this point, we're not making that recommendation. That's correct.

Senator **Nickles**. I appreciate that.

Mr. Chairman, thank you very much.

Senator **Metzenbaum**. Thank you very much.

I want to thank the panel. We will proceed forward with our other panel. There will be additional written questions submitted. We'll ask the members of the panel to respond promptly.

Dr. **Berg**. Yes, sir. Thank you very much.

Senator **Metzenbaum**. I am very sorry. I apologize. Senator Conrad, do you have questions?

Senator **Conrad**. No.

Senator **Metzenbaum**. I totally apologize to you. I intended to call upon you.

Senator **Conrad**. No, Mr. Chairman. You had earlier given me a chance, and due to the number of panelists we have, I'm happy to turn back my time so that we can move on.

Senator **Metzenbaum**. Thank you. But if you have any at any time, if you change your mind, please feel free to ask what ever questions you have.

Senator **Conrad**. I appreciate that.

Senator **Metzenbaum**. We're happy to have you sitting with us. Thank you very much, gentlemen.

Our next panel consists of Mr. Charles Ebinger, Group Manager for Energy Analysis, International Resources Group, Ltd. of Washington; Dr. Marina v.N. Whitman, Vice President and Group Executive, Public Affairs Group of General Motors Corporation of Detroit; Mrs. Helen O. Petrauskas, Vice President, Environmental and Safety Engineering for Ford Motor Company, World Headquarters in Dearborn, Michigan; and Dr. Clarence M. Ditlow III, Executive Director, Center for Auto Safety, Washington, D.C.

I want to say to all parties that the fact that these four are on the same panel is not in any way to suggest, imply or indicate that their positions are anywhere similar to each other. We call them forward to us at this point merely as a matter of convenience to the committee, but for no other reason.

Dr. Marina v.N. Whitman, we're happy to have you with us. The committee is attempting to follow—and I think you heard me say this to the previous witnesses—a five-minute rule for the presentation of testimony. The entire statement will be included in the record. If you feel that you need a couple of minutes more, we'll try to accommodate you.

## STATEMENT OF DR. MARINA v.N WHITMAN, VICE PRESIDENT AND GROUP EXECUTIVE, PUBLIC AFFAIRS STAFFS GROUP, GENERAL MOTORS CORP.

Dr. **Whitman**. Thank you, Mr. Chairman.

I'm Marina Whitman, Vice President and Group Executive in charge of the Public Affairs Group for General Motors Corporation, and I am pleased to have this opportunity to discuss our views on proposals to raise the fuel economy standards.

We believe that any regulatory program should meet three tests. It should be effective. It should be efficient. It should be fair. Both the current CAFE program and proposals to raise the CAFE standards flunk these tests.

Concerning effectiveness, independent research and our own experience demonstrates conclusively the two factors, actual and/or anticipated increases in gasoline prices and perceived availability, not CAFE, drive consumer choice regarding the characteristics of the cars they buy. Both factors are beyond our control.

Concerning efficiency, independent research has shown that a CAFE standard that would actually increase fuel economy would do so only at a very high cost to the public.

Concerning fairness, CAFE affects only a single use of energy, and to the extent that emissions of so-called greenhouse gases are of concern, CAFE targets the source of a remarkably small share of any forecasted global warming impact.

Moreover, CAFE unfairly impacts domestic full-line manufacturers such as GM while it creates an incentive for our Japanese competitors to produce larger cars, cars that in some cases actually get poorer fuel economy than directly competitive GM vehicles.

With fuel prices stabilized and strong consumer demand for family size cars and better performing engines, CAFE is working against American workers and car makers. Since 1974 GM has increased its fuel economy by 130 percent. However, because sales of larger cars shift the CAFE average downward, trying to comply with CAFE seriously inhibits our ability to give American consumers what they want.

Meanwhile, Japanese and other traditionally small car producers face no CAFE constraints. In fact, several Japanese manufacturers have aggressive plans to bring in larger luxury and mid-size cars with V-8 and performance V-6 engines.

By hindering the ability of U.S. producers to respond to this new competitive challenge, more stringent standards will reduce auto employment in the United States without affecting the mix of vehicles that is actually bought and driven. We believe it would be a serious mistake to raise the CAFE standards.

Research conducted by Andrew Kleit of the Federal Trade Commission's Bureau of Economics shows Japanese firms as benefiting while full-line American producers lose sales and their workers lose jobs if they attempt to alter sales mix in order to force consumers into a fleet having more than a minor increase in CAFE.

A key factor is the ability of consumers to substitute Japanese cars for domestic cars. Another is CAFE's well-documented tendency to cause some potential car purchasers to hold onto their less fuel efficient cars actually increasing energy use. For those ranges where CAFE might result in some net gasoline savings, it does so in Kleit's words "at an exorbitant cost to the economy".

Exotic experimental vehicles that have achieved very high fuel economy at GM and elsewhere are not evidence that cost effective technology exists These highly optimized, experimental subcompacts do not have the utility and performance characteristics demanded by an overwhelming majority of consumers.

In fact, there are small, attractively priced subcompact models on the market today that exceed 50 miles per gallon. They include the GM Geo Metro which obtains a composite CAFE rating of 65 miles per gallon and is the most fuel efficient in the EPA's Buyer's Guide. However, sales of all vehicles with fuel economy greater than 50 miles per gallon were only 1 percent of total U.S. car sales in 1988.

Looking to the future, GM has extensive research efforts focused on using methanol and ethanol and improving the efficiency of the internal combustion engine including, for example, two-cycle engines, direct injection diesel engines, and ceramic gas turbines.

GM is also active in research and development of non-fossil fuel energy sources. Current programs include fuel cell research, electric vehicle programs, and the solar-powered Sunraycer.

In addition, GM is actively engaged in research to reduce congestion and thereby also reduce petroleum consumption, as well as emissions. However, there are no technological breakthroughs affecting fuel economy on the immediate horizon.

In recent months concern about global warming has added a new dimension to the discussion of energy conservation. The policy question at this point is whether and what kinds of insurance might be reasonable. Beyond encouraging the research necessary to reduce the scientific uncertainties, GM supports the ongoing search for a practical multilateral approach because of the global scope of the issue. Importantly, actions by the U.S. alone would in themselves be marginally effective and could result in economic and competitive disadvantages for the United States.

Wouldn't it make better sense to create incentives to induce all emitting sources to reduce their emissions rather than focus attention virtually exclusively on one particular activity in responding to the concern about global warming?

For example, a number of commentators, including EPA's staff in a recent draft policy paper, have suggested a greenhouse or carbon fee. Because carbon dioxide is a byproduct of all types of fossil fuel combustion, wouldn't a fee structure tied to the level of carbon content of various fossil fuels be the fairer approach as well as more effective?

These are among the questions that need to be addressed promptly.

CAFE does not alter demand. Currently all that CAFE is doing is moving the customer around in the marketplace among manufacturers at the expense of U.S. full-line manufacturers and their workers. Incremental increases in the standards would only aggravate this problem, and increases to levels draconian enough that CAFE could conceivably result in a net fuel savings would at best be exorbitantly expensive and so disruptive that the impact would not be acceptable to the American public.

Thank you, Mr. Chairman.

[The prepared statement of Dr. Whitman follows:]

Record Statement

Statement of

General Motors Corporation

Submitted to the

Senate Subcommittee on Energy
Regulation and Conservation

Presented by

Dr. Marina v.N. Whitman

Vice President and Group Executive
Public Affairs Staffs Group

April 4, 1989
Washington, D. C.

Mr. Chairman. I am Dr. Marina v.N. Whitman, vice-president and group executive in charge of the Public Affairs Group for General Motors Corporation. I am pleased to have this opportunity to discuss our views on the proposed legislation to raise the fuel economy standards. I also will discuss briefly our views on the global warming issue and indicate why we believe that an increased Corporate Average Fuel Economy (CAFE) is ill-suited as a response to it.

We believe that any government regulatory program should meet three tests: It should be effective, it should be efficient, and it should be fair. Both the current CAFE program and the proposal we are discussing today to raise CAFE flunk all three of these tests. Concerning effectiveness, independent research as well as our own experience demonstrates conclusively that actual and/or anticipated increases in gasoline prices and perceived availability, not CAFE, is what has driven consumer choice regarding the characteristics of the cars they have purchased. This implies that it has been the path of fuel prices, not CAFE, that has been overwhelmingly responsible for the improvements in motor vehicle fuel economy experienced over the last couple of decades. Concerning efficiency, independent research has shown that a CAFE standard level that would actually increase automotive fuel economy, would do so only at a very high cost to the public. Concerning fairness, CAFE affects only a single use of energy and, to the extent that emissions of so-called "greenhouse gases" are of concern, CAFE targets the source of a remarkably small share of these gases on a worldwide basis. Moreover, CAFE unfairly impacts a particular subset of vehicle producers, namely, domestic full-line manufacturers such as GM, while it creates an artificial incentive for our

Japanese competitors to produce larger cars — cars that in some cases actually get poorer fuel economy than GM cars against which they directly compete.

I'll address each of these defects with CAFE more fully in the body of my statement.

Before proceeding further, it is important to be clear on a bit of terminology. CAFE is sometimes justified by its supporters on the grounds that it promotes energy security. This is just not so. Enhancing "energy security" is dependent on increasing demand-side or supply-side energy flexibility in the short-run by diversifying supply sources, developing alternative standby supply sources, or enhancing the ability to switch quickly to alternative fuels. CAFE contributes to none of these goals. So it cannot, even in theory, promote energy security. Rather, CAFE is directed at energy conservation, which is the level of energy use over the longer run. So in judging the effectiveness or ineffectiveness of CAFE, it should be in terms of an energy conservation program, not energy security.

## Energy Conservation and CAFE

With respect to conservation, improvements in fuel efficiency since the early 1970s, when the first oil shock occurred, have indeed been significant. For example, the national average fuel economy of new cars has essentially doubled, from 14 mpg in 1974 to over 28 mpg in 1988. What has produced this improvement? Research by Robert Crandall and his colleagues at Brookings has demonstrated that the CAFE standards have had little, if anything, to do with this improvement. To quote from the principal conclusion of the chapter in their book, Regulating the Automobile, titled "Regulating Fuel Economy": "...the automobile producers' increase in fuel economy is about what one should have expected given the rise in gasoline prices since 1973. The CAFE standards appear to have provided little but nuisance value until recently. [However,] as gasoline prices have fallen in real terms, the standards have become a binding constraint upon producers attempting to satisfy the demand for larger cars." (p. 139)

Such research is consistent with our own experience at GM and the experience of the industry. When gasoline prices were on the rise and were forecast to keep rising, demand for fuel-efficient cars was so strong that we had no difficulty in meeting CAFE standards. In effect, the standards became redundant. But as gasoline prices have fallen, and expectations about their future path have been adjusted downward, we have been unable to induce consumers to purchase cars having high levels of fuel economy. For example, our Geo Metro, the nation's highest-rated fuel economy car with a combined EPA mileage rating of 65 mpg, constitutes only 1.5 percent of our sales today, despite our considerable marketing efforts. And the sale of automobiles with such fuel economy levels are barely 1% of total U.S. sales.

Manufacturers' recent petitions for CAFE relief are thus appropriately seen not as "backsliding" on our part, but as the inevitable result of the growing inconsistency between energy prices and the CAFE standards. Today, both as a result of low gasoline prices and of greatly improved automobile fuel efficiency, the fuel cost per mile is the lowest (in constant dollar terms) it has been at any point in the nation's history for which we can obtain information. Given this, it should be no surprise that we are having difficulty selling very high fuel economy as a desirable product feature relative to other product characteristics like passenger and trunk capacity.

How expensive might it turn out to be to try to use CAFE to force consumers into cars they don't really want in order to conserve energy? A rough idea is given by research conducted by Andrew Kleit of the Federal Trade Commission's Bureau of Economics. Kleit selects a particular year, assumes that CAFE is binding on manufacturers during that year, and then calculates what happens if manufacturers must alter the prices they charge for their cars to try and force consumers into a fleet having a higher CAFE. He takes account of the ability of consumers to be able to offset this by substituting Japanese cars for domestic cars. Thus his model shows Japanese firms as benefitting while American firms lose profits and their workers lose jobs. Kleit finds that for some levels of CAFE increase even the energy impact is the opposite of the intended direction, due to CAFE's well-documented tendency to cause some potential car purchasers to hold onto their older and less fuel-efficient cars for a longer time. For those ranges where CAFE might result in some net gasoline savings, it does so, in Kleit's words, "... at an exorbitant cost to the economy." (p. 25)

Energy Security & CAFE

Regarding energy security, the nation has made substantial progress since the Energy Policy and Conservation Act was passed in 1975. Our ability to deal with energy supply disruptions has greatly increased. Petroleum demand elasticity — the ability to adjust consumption in response to price increases — has proven much greater than most experts had thought possible, both in the short run and in the long run. Likewise, supply elasticities of non-OPEC oil and oil substitutes have proven greater than most had expected. Whereas it was once thought that $100 per barrel petroleum was just around the corner, we now know that even a $40 per barrel price is probably too high to be sustainable.

We believe the best guarantee for assuring national energy security is well-functioning petroleum markets, worldwide. Since the first major oil crisis in 1973, the petroleum markets have been undergoing fundamental structural change which has created many strategic alternatives in the event of Mid-East disruption. First, strategic petroleum reserves, both here and elsewhere around the world, now provide a major cushion. Second, increased output from and reliance on more stable foreign sources such as Mexico, the North Sea, and Canada increases the diversity of supply and makes the Mid-East less critical. Finally, the decontrol of prices for petroleum and partial decontrol of natural gas in the U.S. has promoted the development of switching capacity and alternative supplies.

In addition, increased ability to switch to petroleum substitutes, particularly within industry and electric power plants, provides a major alternative. Because energy security is an important national priority, GM has supported policies, such as the Strategic Petroleum Reserve and price decontrol, that enhance such security. But, to repeat, CAFE standards are unrelated to these improvements in energy security.

## CAFE Assumptions Obsolete

There were three basic assumptions behind the CAFE law, each of which is out of touch with the economic and competitive realities of 1989. The assumptions were: first, that U.S. oil prices would continue to be controlled below world market levels, which would encourage overconsumption; second, that world petroleum prices would keep on rising into the '80s and beyond, reflecting growing scarcity of petroleum-based fuels; and third, that the U.S. auto industry would be able to dictate what consumers would buy. That is, if smaller, less-powerful, more-fuel-efficient cars were what the U.S. industry was directed to build by CAFE, that's what industry could force the U.S. consumer to buy and drive, like it or not.

None of those assumptions holds true today if they ever did. U.S. oil prices have long since been decontrolled and world oil prices have declined in real terms, reflecting an increase in the number of suppliers, available production and resultant excess capacity. Finally, consumers do have a choice from among a record number of models produced by a large number of manufacturers.

With ample supplies of petroleum, increased efficiency and the decontrol of oil prices in 1981, gasoline prices have not come close to the $2.00-$2.50 per gallon which were projected for the mid 1980s by most experts just a few years ago. In fact, inflation-adjusted retail fuel prices have actually dropped to new low levels, levels below that of 1970 and about one-third of what was once predicted.

The combination of ample petroleum supplies and lower than expected gasoline prices has resulted in stronger than anticipated consumer demand for family-size cars and cars with better performance characteristics. These kinds of cars have traditionally been popular with U.S. buyers for the utility, comfort and roominess they offer. Consequently, full-line auto manufacturers such as General Motors are experiencing increasing difficulty in consistently exceeding the 27.5 mpg fuel economy standard established back in 1975.

It is important to note that our current difficulties are not the result of a failure to make product improvements. GM has maintained an on-going commitment to fuel economy improvement across the full-range of its products since before the Arab oil embargo in 1973. Since 1979 alone, GM spent over $50 billion for new products, plant and equipment to provide the capacity and the capability to build a full-range of fuel-efficient cars. We have aggressively downsized our models, made many important powertrain advances and have established aggressive technological goals, which continue to challenge our engineers. As a result, most of today's family-size cars achieve fuel economy that is better than that of many compact models in 1975. Indeed, the average fuel economy of the fleet of GM vehicles produced in 1988 has increased over 130% from model year 1974.

Unquestionably, in our quest to continue to offer the American motorist a full line of vehicles, we have not always achieved the aggressive goals we have set for our engineers. However, we have vigorously utilized the economically practicable technologies that can provide better fuel economy in our cars. The one step we have not taken is to abandon selected segments of the market. GM still attempts to provide vehicles capable of meeting the full range of transportation needs and demands.

Research and experience have both shown that fuel prices and perceived fuel availability are the most important determinants of fleet fuel efficiency. Yet, both factors are beyond the motor vehicle industry's control. As fuel prices increase or decrease, and consumer perceptions about fuel availability change, new car purchasing decisions also change.

Thus, consumers today are reacting in a rational manner to historically low gasoline prices and ample supplies of fuel in purchasing vehicles that satisfy their individual needs and wants. As we work to sharpen the focus on customer satisfaction of our entire organization, the CAFE standards are a particularly difficult obstacle. It is especially true in the case of full-line manufacturers that the CAFE standards can be a direct impediment to satisfying a full range of customer needs — needs that experience suggests will be met regardless of CAFE constraints imposed on the individual manufacturers.

## Manufacturing and Product Developments

In addition to the price and availability of gasoline, other factors that influence consumer demand include general economic conditions, interest rates and the actions of competitors. All these factors are subject to great uncertainty. In 1982, for example, despite our best engineering efforts and capital investments to anticipate increased demand for high fuel efficiency, we were forced to close two assembly plants which had been fully converted to produce our new, highly fuel-efficient compact and mid-size cars. The cost of these conversions was $130 million, but the plants were closed because demand for those cars did not develop during a period of sharply declining gasoline prices. For the same reasons, an engine plant converted at a cost of about $300 million to make engines for small cars and trucks was idled in 1984 for lack of consumer demand.

Today, we have a greater capability to provide a broad array of fuel-efficient engines across a number of products than ever and we have ample capacity for smaller vehicles if consumer demand shifts. This gives us the potential to match changes in consumer demand, thereby dramatically improving our response time. Thus, we are better prepared to handle the future market conditions that may result from a variety of changes that affect the marketplace, including gasoline prices and/or availability.

Moreover, for the intermediate term, General Motors has extensive research efforts focused on improving the efficiency of the internal combustion engine, including for example, two-cycle engines and direct injection diesel engines. Over the longer term, GM is active in research and development of non-fossil fuel energy sources. Current programs include fuel cell research, electric vehicle programs and the solar-powered Sunraycer. GM is also engaged with the government in a five-year joint research effort to develop the components for an experimental automotive ceramic gas turbine engine. Finally, GM is actively engaged in research on intelligent highways to reduce congestion and thereby also reduce both petroleum consumption and tailpipe emissions. However, there are no technological breakthroughs affecting fuel economy on the immediate horizon.

With respect to pursuing alternative fuels such as ethanol and methanol, GM has an active development and demonstration program underway. Our largest effort to date is a demonstration program with the California Energy Commission for 2200 variable-fueled vehicles. In addition, beginning in the 1990 model year, GM's owners' manuals will recommend the use of oxygenated blends which will also have the effect of reducing gasoline consumption, as well as emissions.

## The Impact of Raising the Standard

We believe it would be a serious mistake to raise the CAFE standards since it has proven to be an ineffective energy program -- one that generates serious adverse impacts on consumers as well as full-line automakers and their workers.

The inequities and job-endangering characteristics of the CAFE approach are illustrated by today's situation. The CAFE standard is the same for all auto manufacturers, but it has a different impact on different manufacturers depending on the types of vehicles they build. Meeting the standard is most difficult for a manufacturer like GM that produces a full line-up of vehicles from small cars to large station wagons. Meeting the standard is easy for companies that have traditionally specialized in small cars. In Japan, for a variety of reasons, domestic demand has historically focused on smaller cars, and Japanese companies have specialized in smaller vehicles. As a result, their CAFE is in excess of the standard. One of the most perverse aspects of the CAFE law is its positive incentive to induce the Japanese manufacturers to build larger vehicles — some of which achieve poorer fuel economy than some of our larger vehicles. This is the natural result of U.S. policy that favors them at the expense of U.S. full-line manufacturers.

With fuel prices stabilized and strong consumer demand for family-size cars and better-performing engines, CAFE is working against the interests of American workers and carmakers. Because sales of larger cars shifts the CAFE average downward, trying to comply with these rules seriously inhibits our ability to respond to consumer demand. As mentioned earlier, CAFE doesn't alter this demand. Meanwhile, Japanese and other small-car producers face no CAFE restraints due to their large base of small cars. And they are going after this large-car market segment aggressively, including plans to bring in cars with V-8 engines. In fact, several Japanese manufacturers have plans to bring in larger luxury and mid-size cars with V-8 and performance V-6 engines providing direct entry into the market segments in which U.S. automakers have been particularly strong. By hindering the ability of U.S. producers to respond to the new competitive challenge of the Japanese, more stringent standards will result in reduced auto employment in the United States, without necessarily affecting the mix of vehicles that is actually bought and driven.

It is important to point out that the Japanese have recently made several changes in their tax laws that will reduce significantly the higher taxes on vehicles with relatively larger engines. Again, these changes come as the Japanese are moving aggressively into the market for larger, luxury vehicles. Removal of the tax penalty for larger engines thus will help the Japanese manufacturers build a market for luxury cars in Japan and help them in their efforts to sell more upscale models in the United States.

Indeed, the average fuel economy of Japanese imports is declining. For example, a popular Japanese compact car is rated at 24 miles per gallon while GM's top-of-the-line full-size Buick Electra is at 25 miles per gallon. Thus, restricting production of Buicks and driving customers to foreign cars will not conserve fuel.

While attempts to include an "anti-backsliding" provision may present new constraints for traditional small-car manufacturers as they consider their possible compliance strategies, the full-line manufacturers will still be hurt more under this proposal. For example, the major Japanese automakers will not have to start increasing their CAFE's until the standard reaches 30-32 mpg because they are all around that level presently. Under the proposal, these levels are reached in the 1993-1996 timeframe. In addition, the Japanese companies have a greater line-up of high mileage cars which they can try to use through increased sales efforts to marginally increase their CAFE, if necessary.

Technology

Some have pointed to exotic experimental vehicles as evidence that cost-effective technology exists and is not being introduced. While certain highly optimized experimental subcompacts have attained very high fuel economy values, such vehicles do not have many of the utility and performance characteristics demanded by an overwhelming majority of consumers. But, again, while there are small, attractively priced subcompact models on the market today that exceed 50 mpg (EPA composite), including the GM Geo Metro which obtains a CAFE rating of 65 mpg and is the most fuel efficient vehicle in the Environmental Protection Agency (EPA) Buyer's Guide, such models represent barely 1% of U.S. sales in 1988.

## Safety

I have raised serious doubts regarding whether the CAFE standard does in fact affect fuel economy. But, to the extent that it does force an increase in the sales of smaller cars, there are complex safety implications that need to be understood. All other things being equal, mass is a major element of the basic principles of physics that apply in vehicle crashes. The safety research literature confirms a statistical relationship between vehicle weight and occupant fatality risk. Of course, the complexity of the other variables makes absolute correlation of CAFE and safety risks impossible. But, the issue likewise cannot be ignored. Research by Crandall and Graham has estimated the adverse impact on safety that an increase in the number of smaller cars (produced because of a binding CAFE level) might have. Assuming that the standards are binding in 1989, Crandall and Graham conclude that the larger share of model year 1989 cars that result from "mix forcing" "...will be responsible for 2,200 to 3,900 additional fatalities over the next ten years because of CAFE." (Robert Crandall and John D. Graham. "The Effect of Fuel Economy Standards on Automobile Safety," (draft, revised March 1988, p. 31.)

## Global Warming

In recent months, concern about possible global warming has added a new dimension to the discussion of energy conservation. Combustion of fossil fuels, including gasoline and diesel fuel, produces carbon dioxide (CO2), a "greenhouse gas." Currently, passenger cars account for 13% and trucks and buses account for 10% of total U.S. carbon dioxide emissions. On a global basis, this represents about 5% of all carbon dioxide emissions and about 3% of the forecast greenhouse impact, if trace gas emissions (e.g., chlorofluorocarbons and methane) are included.

Because the global warming issue has long-term implications with many scientific uncertainties, we believe strongly that realism, responsibility and reason must prevail in considering its implications for public policy. We support responses that are in proportion to our knowledge and tailored to the time horizon of the issue. The policy question at this point is whether and what kinds of "insurance" might be reasonable. In evaluating different policy options, I would like to reiterate, we believe effectiveness, least cost to the U.S. economy and lifestyle (efficiency), and fairness must be the decision criteria.

Beyond encouraging the research necessary to reduce the scientific uncertainties, GM supports the ongoing search for a practical multilateral approach already begun under the auspices of the United Nations. This is essential because of the global scope of the issue. Importantly, actions by the United States alone will in themselves be marginally effective in slowing the increase in global carbon dioxide emissions and could result in economic and competitive disadvantages for U.S. goods and services in world markets.

Beyond this, it is inefficient, unfair and unnecessarily disruptive to focus attention virtually exclusively on one particular activity in responding to concern about the impact of burning fossil fuels and the formation of carbon dioxide emissions on the environment. Wouldn't it make better sense to create incentives to induce all emitting sources to reduce their emissions? For example, a number of commentators, including the EPA staff in a recent draft policy paper, have suggested a "greenhouse" or carbon fee. Because CO2 is a byproduct of all types of fossil fuel combustion, wouldn't a fee structure tied to the level of carbon content of various fossil fuels be the fairer approach as well as a more effective approach? These are among the questions that need to be answered promptly.

By contrast, as described previously, increasing the CAFE standard is unfair and far more economically disruptive because it would place the efficiency burden on only one fuel and one fuel use. Such a policy would, to the extent that it had the desired effect, generate very high costs and could, in fact, detract from the search for effective and less disruptive measures.

Summary

Most economists and energy analysts agree that gasoline consumption is most influenced by changes in perceived energy availability and price. It has been the combination of these factors, rather than CAFE, that has had the dominant impact on automobile fleet fuel efficiency improvements over the last couple of decades. When petroleum prices rose, as they did from 1973 to 1981, overall fuel economy rose. When gasoline prices declined, consumer interest in fleet fuel efficiency did the same.

While one could in theory legislate CAFE increases drastic enough to reduce gasoline consumption, such gains would be very expensive to consumers as well as U.S. full-line automakers and their workers. The costs would stem from higher product prices, increased fuel consumption (caused by motorists keeping their old cars longer), and the sales lost to imports, which can be sold at lower prices since they do not face CAFE-generated costs. To quote Kleit's conclusion: "CAFE standards may or may not generate reductions in gasoline consumption. If they do, it is only at a very large cost to the economy." (p. 2)

As older, less-fuel-efficient vehicles are replaced with newer, increasingly efficient ones, the average fuel economy of the passenger car fleet will increase by a minimum of 30% by the late 1990s. Further, GM has an aggressive program for continued introduction of new, more fuel-efficient and cost-competitive cars and engines which will soon come on stream, many of which are aimed at the small car segment currently dominated by Asian imports. GM continues to pursue technologically feasible and economically practicable compliance actions. The major point to remember is that significant reductions have been made in fuel consumption. Further improvements in fuel efficiency will be incremental, whatever legislative requirements are imposed.

Currently, all that CAFE is doing is moving the customer around among manufacturers in the marketplace at the expense of U.S. full-line manufacturers and their workers. Incremental increases in the standards would only continue this problem. And, increases to levels draconian enough that CAFE could conceivably result in a net fuel savings would at best be exorbitantly expensive and would be so disruptive that the impact would not be acceptable to the American public.

In closing, as Congress considers energy issues, we urge you to look at proposals from the perspective of effectiveness, efficiency and fairness. We oppose the CAFE program because it fails all three of these basic tests.

* * * *

Senator **Metzenbaum**. Thank you very much.

We will now hear from Mrs. Helen O. Petrauskas, Vice President of Environmental and Safety Engineering for Ford. I think my recollection is that you testified before our committee many years ago. Am I correct about that?

Mrs. **Petrauskas**. Yes, I did.

Senator **Metzenbaum**. We're happy to have you with us again.

## STATEMENT OF HELEN O. PETRAUSKAS, VICE PRESIDENT, ENVIRONMENTAL AND SAFETY ENGINEERING, FORD MOTOR CO.

Mrs. **Petrauskas**. Thank you, Mr. Chairman. We appreciate the opportunity to be here and comment on fuel economy standards.

Ford fully recognizes the role of the automobile in many important societal issues, and we want to help identify workable approaches to these issues. These issues are interrelated and they substantially affect the consumer. We believe it's important to be clear about the policy goals that are being addressed. Higher fuel economy standards have been proposed to address petroleum conservation, air quality and global climate concerns.

If the objective is to conserve petroleum, there is a role for vehicle fuel economy improvement, along with improvement in other energy using sectors, but increased use of alternate fuels we believe offers greater potential.

If the objective is to improve the air quality, higher fuel economy standards will have no effect because vehicle emissions are controlled on a gram-per-mile basis which eliminates any differences in emissions among vehicles. Tighter emission standards, in fact, will reduce vehicle fuel economy. The most promising transportation sector opportunities are to reduce excess evaporative emissions, to reduce vehicle running losses, to reduce fuel volatility and to make greater use of alternate fuels that inherently produce lower emissions.

If the objective is to reduce emissions of gases believed to contribute to global warming, higher CAFE standards will only have a minimal effect. We estimate that even a doubling of the fuel economy of the U.S. car fleet would reduce the buildup of global warming by one-half of one percent. On the other hand, reducing the use of chlorofluorocarbons offers the greatest opportunity in the transportation sector although, as was noted in earlier testimony, redesigning automotive air conditioners for CFC substitutes presents a major engineering task and is likely to reduce fuel economy. Again, alternative fuels may offer some potential in this area as well.

Ford wants to do——

Senator **Metzenbaum**. Before you proceed further, would you want to comment on the fact that your figure is so far different from the EPA's?

Mrs. **Petrauskas**. You know, I listened very carefully to Dr. Morganstern's answer, and I believe there really isn't an inconsistency.

Senator **Metzenbaum**. He said 2 to 3 percent. You say one-half of 1 percent.

Mrs. **Petrauskas**. He said 1 to 2 percent. I said a half of one percent. I believe the explanation or the apparent difference is today our new car fleet, for example, Ford Motor Company, is at 26.6

roughly I believe. The entire new car fleet is over 27 and a half. The in-use fleet, what's out there, is at about 19. That 19 will—each year as newer, more efficient cars are produced and sold, that 19 average that is out there will over time become the average of the new car fleet, that is, something above 27.

The half a percent that I referred to is the increment between having today's standard, which is somewhere between 26 and a half and 27 and a half, and a doubling of that standard.

I don't presume to put words into Dr. Morganstern's mouth, but what he I believe is talking about is the difference between the 19 that is out there today and a doubling of the new car standard.

Ford wants to do its part in all of these areas. First, petroleum consumption can be reduced by increased reliance on alternative fuels. Ford has a fleet of nearly 700 vehicles on the road that operate on methanol. We are currently negotiating with California for delivery of at least 2,500 vehicles that can operate on methanol, ethanol, gasoline or any combination of those fuels. The alternative fuel legislation cosponsored by Senator Rockefeller and many other members of this committee and enacted in the last Congress will help encourage production of such vehicles.

Toward the goal of improving air quality, Ford is prepared to redesign its emission control and fuel systems to substantially reduce evaporative emissions which occur on hot days while the vehicle is parked and running losses which occur under similar conditions while the vehicle is moving. These actions could reduce ambient hydrocarbon levels by 25 percent, assuming that fuel volatility levels are restored to those of the early 1970s.

On the issue of global warming where a reduction of CFCs would have the greatest impact, Ford has an aggressive program to identify what it will take to phase out the automotive use of CFCs as soon as possible. Ford is also investigating installation of CFC recycling equipment in dealerships and potential retrofit hardware for existing vehicles so that new CFC alternative blends can be used.

Of these three policy goals, higher fuel economy standards could play a major role in only one, and that is reducing petroleum usage. Ford is committed to continuous improvements in the fuel economy of its vehicles through implementation of new technology. However, the corporate average fuel economy approach has proven to be a poor measure of a manufacturer's technical effort because application of technology to improved fuel economy can be offset easily by market changes.

A manufacturer's CAFE levels are strongly dependent on the mix of small and large cars customers are actually buying, as well as the consumer demand for larger engines, automatic transmissions, air conditioning and other power consumption options. For example, customer demand for automatic transmissions in Ford vehicles has increased from 80 percent in 1985 to 87 percent in 1989. Similarly, air conditioning installation has risen from 73 percent in 1985 to more than 90 percent in 1989.

Changes in consumer demand in the past several years have caused Ford's CAFE to plateau. This has occurred despite our introduction of extensive new technology and emphasis on small car sales.

CAFE standards also put domestic full-line manufacturers at a competitive disadvantage. CAFE is an average of all cars, small, mid-size and large, sold by a manufacturer. If a manufacturer makes only small cars, as some Asian manufacturers do, it easily meets the standard. A manufacturer only making top-end cars, for example, Rolls Royce or Mercedes, has little hope of meeting the standard. Domestic full-line producers can meet CAFE standards only by selling enough small cars to offset their larger car sales.

If Ford or another full-line U.S. manufacturer cannot meet consumer demand for larger vehicles because of CAFE constraints, and if a foreign manufacturer is able to provide such vehicles and still meet its CAFE requirements, there is no energy saving, but there is a loss of U.S. production and jobs.

In addition, other government standards have very substantial effects on CAFE. Since the fuel economy standards were enacted in 1975, many other significant regulatory requirements have been added, including a 73 percent reduction in tailpipe emissions and major new safety standards that add substantially to vehicle weight. In the next few years manufacturers must offset the reduced fuel economy that accompanies across the board implementation of passive restraints and expected tighter Federal and California emission requirements. We estimate the impact of these requirements to be at least a mile per gallon in CAFE.

Ford also wants to respond to consumer interest in improved safety, an interest which is more difficult to satisfy with smaller, lighter vehicles.

Furthermore, an unrealistically high CAFE level will severely restrict consumer choice. Today only 13 percent of the new car models offered in the United States exceed 34 miles per gallon. All of the models equipped with gasoline engines are compact size or smaller. New technologies are not expected to produce quantum increases in fuel economy, but rather incremental improvements. Therefore, under a 34 mpg standard, a manufacturer could produce only a few vehicles larger than Ford's compact size Escort and still meet the standard. Consumer needs for greater passenger carrying capacity, cargo room and towing capability could not be met.

The studies often cited to support high CAFE levels are based on concept vehicles that use diesel technology, weigh no more than 900 to 1,900 pounds, carry two to four passengers and generally do not meet U.S. safety or emission requirements.

It is interesting to note that a recent EPA report cites European new car fleet averages in the mid-1980s as being in the low 30 mile per gallon range despite smaller engine displacements, smaller cars and comprehensive government measures in many countries that encourage the purchase of fuel efficient vehicles.

In view of these inherent problems with CAFE, if Congress decides on further automotive fuel economy improvement goals, we urge the following.

First, that measures not penalize a manufacturer for the effect of changing market preference perhaps by establishing a constant sales mix.

Second, that an equal percentage improvement goal be applied to all manufacturers selling vehicles in the U.S.

Third, that a long-term goal rather than year over year requirements be adopted.

Fourth, that the fuel economy goals be adjusted automatically for changes in safety and emission requirements.

And finally, that the goals be set at a level where the full range of American transportation needs can be met.

Also, the government should consider aggressive fleet demonstration programs for alternative fuel vehicles, as well as incentives to encourage consumer interest in such vehicles. We must also reach a consensus on the role of alternative fuels in addressing global warming.

Finally, government should also consider a greenhouse or a carbon fee that might be applied to all fuels that emit carbon dioxide when burned.

Thank you, Mr. Chairman. I've taken more than my time. I apologize.

[The prepared statement of Mrs. Petrauskas follows:]

Statement of Helen O. Petrauskas
Vice President, Environmental and Safety Engineering
Ford Motor Company
Senate Energy and Natural Resources Committee
Subcommittee on Energy Regulation and Conservation
April 4, 1989

Ford appreciates the opportunity to comment on automotive fuel economy standards. Increases in these standards would have major impacts on the domestic industry and consumer choice that need to be considered by the Committee.

Ford fully recognizes the role of the automobile in many important societal issues and wants to help identify workable approaches to these issues. These issues are interrelated and substantially affect the consumer. So we must be clear about the policy goals that are being addressed. Higher fuel economy standards have been proposed to address petroleum conservation, air quality and global climate concerns.

- If the objective is to conserve petroleum, there is a role for vehicle fuel economy improvement along with improvement in other energy-using sectors, but increased use of alternative fuels offers greater potential.
- If the objective is to improve air quality, higher fuel economy standards would have no effect because vehicle emissions are controlled on a grams-per-mile basis, which eliminates any emissions differences among vehicles. Tighter emissions standards, in fact, will reduce vehicle fuel economy. The most promising transportation sector opportunities are to reduce excess evaporative emissions and vehicle running losses, to reduce fuel volatility and to make greater use of alternative fuels that inherently produce lower emissions.
- If the objective is to reduce emissions of gases believed to contribute to global warming, higher CAFE standards will have only a minimal effect. Ford estimates that even a doubling of the fuel economy of the entire U.S. car fleet would reduce the build-up of global warming gases by one-half of one percent. Reducing the use of chlorofluorocarbons (CFC) offers the greatest opportunity in the transportation sector, although redesigning

automotive air conditioners for CFC substitutes presents a major engineering task and is likely to reduce fuel economy. Some alternative fuels offer potential in this area as well.

Ford wants to do its part in all of these areas. First, petroleum consumption can be reduced by increased reliance on alternative fuels. Ford has a fleet of nearly 700 vehicles on the road that can operate on methanol. We are currently negotiating with California for delivery of at least 2,500 vehicles that can operate on methanol, ethanol, gasoline or any combination of these fuels. The alternative-fuel legislation cosponsored by Senator Rockefeller and many other members of this Committee and enacted in the last Congress will help encourage production of such vehicles.

Toward the goal of improving air quality, Ford is prepared to redesign its emissions control and fuel systems to substantially reduce evaporative emissions, which occur on hot days while the vehicle is parked, and running losses, which occur under similar conditions while the vehicle is moving. These actions could reduce ambient hydrocarbon levels by 25 percent, assuming that fuel volatility levels are restored to those of the early 1970s.

On the issue of global warming, where a reduction of CFCs would have the greatest impact, Ford has an aggressive program to identify what it will take to phase out the automotive use of CFCs as soon as possible. Ford also is investigating installation of CFC recycling equipment in dealerships and potential retrofit hardware for existing vehicles so that new CFC-alternative blends can be used.

Of these three policy goals, higher fuel economy standards could play a major role in only one -- reducing petroleum usage. Ford is committed to continuous improvements in the fuel economy of its vehicles through the implementation of new technology. However, the corporate average fuel economy (CAFE) approach has proven to be a poor measure of a manufacturer's technical effort because application of technology to improve fuel economy can be offset easily by market changes.

A manufacturer's CAFE levels are strongly dependent on the mix of small and large cars customers are actually buying, as well as by consumer demand for larger engines and automatic transmissions, air conditioning and other power-consuming options. For example, customer demand for automatic transmissions in Ford vehicles has increased from 80 percent in 1985 to 87 percent in the 1989 model year. Similarly, air conditioning installation has risen from 73 percent in 1985 to more than 90 percent in 1989. Such changes are outside a manufacturer's control.

Changes in consumer demand in the past several years have caused Ford CAFE to plateau. This has occurred despite our introduction of extensive new technology and emphasis on small car sales. To maintain high levels of small cars (it takes about two small-car sales to offset one large car), Ford has invested some $3 billion (since 1982) in rebates and other marketing incentives for the purchase of our most fuel-efficient vehicles. We also have kept small-car price increases at about one-third the rate of inflation.

CAFE standards also put domestic full-line manufacturers at a competitive disadvantage. CAFE is an average of all cars -- small, mid-size and large -- sold by a manufacturer. If a manufacturer makes only small cars -- as some Asian manufacturers do -- it easily meets the standards. A manufacturer making only top-end cars -- for example, Rolls Royce or Mercedes -- has little hope of meeting the standards. Such European manufacturers have elected to pay penalties in order to continue participation in the U.S. market. Domestic full-line producers can meet CAFE standards only by selling enough small cars to offset their larger cars sales. Ford does not consider paying penalties an option because of the "unlawful conduct" provision in the law.

If Ford or another full-line U.S. manufacturer cannot meet consumer demand for larger vehicles because of CAFE constraints, and if a foreign manufacturer is able to provide such vehicles and still meet its CAFE requirement, there is no energy savings but there is a loss of U.S. production and jobs.

In addition, other government standards have very substantial effects on CAFE. Since fuel economy standards were enacted in 1975, many other significant regulatory requirements have been added, including a 73 percent reduction in tailpipe emissions (of a total 90 percent reduction) and major new safety standards that add substantially to vehicle weight. In the next few years, manufacturers must offset the reduced fuel economy that accompanies across-the-board implementation of passive restraints and expected tighter federal and California emissions requirements. We estimate the impact of these requirements will be at least a one-mile-per-gallon reduction in CAFE. Ford also wants to respond to customer interest in improved safety, an interest which is more difficult to satisfy with smaller, lighter vehicles.

Furthermore, an unrealistically high CAFE level will severely restrict consumer choice. Today, only 13 percent of the new car models offered in the United States exceed 34 mpg. All of the models equipped with gasoline engines are compact size or smaller. New technologies are not expected to produce quantum increases in fuel economy, but rather incremental improvements. Therefore, under a 34 mpg standard, a manufacturer could produce only a few vehicles larger than Ford's compact-size Escort and still meet the standard -- consumer needs for greater passenger-carrying capacity, cargo room and towing capability could not be met.

The studies often cited to support high CAFE levels are based on concept vehicles that use diesel technologies, weigh no more than 900-1,900 pounds, carry two to four passengers and generally do not meet U.S. safety or emissions requirements. It is interesting to note that a recent EPA report cites European new-car fleet averages in the mid-1980s as being in the low 30-mile-per-gallon range, despite smaller engine displacements, smaller cars and comprehensive government measures in many countries that encourage the purchase of fuel-efficient vehicles.

In view of these inherent problems with CAFE, if Congress decides on further automotive fuel economy improvement goals, we urge:

- that measurement not penalize a manufacturer for the effects of changing market preferences, which are outside its control -- perhaps by establishing a constant sales mix to be used as a base for demonstrating progress;
- that an equal percentage improvement goal be applied to all manufacturers selling vehicles in the United States;
- that a long-term goal, rather than year-over-year requirements, be adopted in order to reduce the cost to consumers and recognize manufacturer lead time constraints;
- that the fuel economy goals be adjusted automatically for any changes in safety and emissions requirements; and
- that the goals be set at a level where the full range of American transportation needs still can be met.

Other congressional actions can help progress on fuel economy and environmental objectives. For example, government should consider aggressive fleet demonstration programs for alternative-fuel vehicles as well as incentives to encourage consumer interest in such vehicles and an expansion of the fuel-supply base. We also must reach a consensus on the role of alternative fuels in addressing global warming concerns before more resources are devoted to these programs.

Government also should consider a "greenhouse" or "carbon" fee that might be applied to all fuels that emit carbon dioxide when burned -- at whatever source. Such a fee, which would be tied to a fuel's relative carbon content, would encourage the use of alternative, lower-emitting fuels as well as reduce petroleum consumption throughout the economy. The fee should be set at a level that will promote these goals without severe impacts on any sector. In the motor vehicle sector, automobile users would be expected to purchase more fuel-efficient vehicles and reduce the number of miles they drive.

Ford also supports public and private sector efforts to identify the most promising "breakthrough" fuel economy technologies. Ford could support a "pooling" of industry and government research efforts on energy and environmental technologies. Part of the revenue from a greenhouse fee might be used to fund basic research on such technologies. Some modification in U.S. law might be required to permit automotive manufacturers to work together.

In summary, it is important to note the progress already made in improving the fuel economy of motor vehicles -- progress that probably has not been matched in any other energy-consuming sector. The replacement for a ten-year-old car gets double the fuel economy of its predecessor. This alone assures a continuous improvement in the fuel economy of each model year's new-car fleet. Coupling this progress with commitments by manufacturers to continuous fuel economy improvement, appropriate industry-government research and acceleration of alternative-fuel programs should allow the nation to reach the energy conservation goals identified by this Committee.

Senator METZENBAUM. Thank you, Mrs. Petrauskas.

I think we will go ahead and hear all of our witnesses first.

Senator WIRTH. Mr. Chairman, if I might briefly intervene. I'm sorry. I have to go to the first markup on this whole S&L business on the Banking Committee. But I want to thank you very much for holding this hearing, and thank you very much, Senator Nickles for pushing to get this to happen. I think we have certainly raised the issue, at least getting it going. Thank you, Mr. Chairman.

Senator METZENBAUM. Thank you very much for your cooperation, Senator Wirth. We look forward to working with you.

And I might say that Senator Rockefeller had to leave because he had another conflict and also wanted the opportunity to submit some questions. He has a strong interest in this subject and has evidenced that over a period of time. Thank you.

Our next witness is Mr. Clarence Ditlow III, Director of the Center for Automotive Safety.

## STATEMENT OF CLARENCE M. DITLOW III, DIRECTOR, CENTER FOR AUTO SAFETY

Mr. DITLOW. Mr. Chairman and Senator Nickles, thank you.

The motor vehicle fuel economy standards mandated by Congress are the most significant energy conservation program in this country and should be sharply strengthened. The 1989 vehicle fleet will consume 2.5 million barrels per day less gasoline than what it would have if the fleet had the same fuel economy as in 1975 when the mileage standards were first enacted.

Despite the dramatic benefits of the CAFE standards, the past administration has waged the regulatory equivalent of war against them. DOT did a complete about-face on post-1985 CAFE standards going from proposing a 41.7 mile per gallon CAFE for 1990 and 47.8 for 1995 to actually relaxing the 27.5 mile per gallon standard.

As a result of DOT's failure to issue more stringent CAFE standards beyond 1985, coupled with its other relaxations, the Nation will consume an extra 600,000 barrels per day of gasoline in 1990. Since it takes almost two barrels of petroleum to produce a barrel of gasoline, the U.S. must import or produce another million barrels per day of petroleum to offset the CAFE loss. Besides making the Nation more dependent on foreign oil, this policy increases air pollution and global warming.

DOT itself recognizes that oil imports are higher now than when the energy act was passed with 6.35 million barrels per day imported in 1988 versus 5.85 in 1975. And it could go up to 10.5 million barrels per day by 1995 and 11.7 by the year 2000. Just on an energy supply and demand basis, there is a greater need now than when EPCA was passed to conserve energy by improved fuel efficiency.

A major new reason to conserve energy and increase CAFE is the greenhouse effect, the buildup of carbon dioxide levels in the atmosphere causing a gradual warming of the earth's temperature. Most scientists recommend that carbon dioxide emissions be reduced by 20 to 50 percent in the near term and long term, respectively. Since 30 percent of all carbon dioxide emissions in the U.S.

come from transportation, this goal cannot be attained unless CAFE standards are increased.

Ford and General Motors allege lost sales and jobs if the CAFE standards are strengthened. But close examination of the results of CAFE relaxations to date show that this is wrong. If anything, the relaxation of the CAFE standards the last three years have allowed the domestic auto companies to export small car production and U.S. jobs abroad.

In 1984 when the CAFE standard was 27, GM and Ford sold less than 1,500 captive imports, cars made outside the U.S. and Canada and not counted toward the company's domestic CAFE. In order to meet the stringent CAFE standards for 1984-85, GM and Ford had to produce as many small cars as possible domestically, but with the relaxation of CAFE standards, Ford and GM pursued a new strategy of making small cars abroad because they were no longer needed for CAFE compliance. Thus, by 1988, GM and Ford had upped their import sales to over a half a million. And if, in fact, these cars had been made domestically, both Ford and GM could have gained seven-tenths of a mile per gallon in CAFE while creating 175,000 more jobs in the U.S.

In relaxing the 27.5 mile per gallon CAFE standard the past three years, DOT has set standards lower than what the manufacturers could achieve. And, in fact, if one simply looks at it, we see that GM in 1988 met a 27.6 standard when DOT had set the standard at 26. Ford hit only 26.4, but that was because it was relying on CAFE credits to meet the standard.

CAFE itself can be increased with improved technology and without restricting consumer choice in the marketplace. The 1981 DOT analysis of post-1985 fuel economy projected a 48 mile per gallon 1995 CAFE based on improvements in technology without restricting large car sales. Some of the better technologies projected included continuously variable transmissions, multi-valve engines, better materials and direct injection diesels.

Just one good example of how performance in fuel economy can be improved is shown by the increased use of four-valve per cylinder engines which can improve fuel economy by 20 to 25 percent while decreasing acceleration time. DOE pointed out that the 1988 Pontiac Grand Am with the four-valve engine got 22.4 percent better fuel economy than the four pound lighter V-6 Chevrolet Beretta while doing 0 to 60 a half a second faster.

As this chart which has just been placed over here shows, it compares two very similar cars made in 1988, the Toyota Camry to the Ford Tempo. The primary difference between the two vehicles is that the Camry is a four-valve per cylinder engine, and even though it is nearly 100 pounds heavier than the Tempo, it gets almost 20 percent better fuel economy and does 0 to 60 a full 1.6 seconds faster than the Tempo. Toyota has found this technology to be so impressive that all its 1988 models were three or four-valves per cylinder engines. And if one simply looks down, the weight is almost identical. The engine size is a little smaller than the Toyota. The four-valves per cylinder is the primary difference. They are both five-speed manuals with a very similar rear axle ratio, and the primary difference is the better fuel economy of the Toyota.

Senator METZENBAUM. Mr. Ditlow, can you wind up please?

Mr. DITLOW. Yes.

The question for CAFE is not whether CAFE should be increased but by how much. An increase to 34 miles per gallon is a modest increase that simply prevents further backsliding. The Center has proposed to DOT that CAFE standards for cars be doubled to 55 miles per gallon by the year 2001 and that commensurate CAFE improvements be set for light trucks and vans. And these higher standards are needed to conserve energy, reduce carbon dioxide emissions and reduce the export of small car production and American jobs abroad.

Thank you.

[The prepared statement of Mr. Ditlow follows:]

### STATEMENT OF CLARENCE M. DITLOW III
### DIRECTOR, CENTER FOR AUTO SAFETY
### Before the
### ENERGY REGULATION AND CONSERVATION SUBCOMMITTEE
### SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES
### Washington, D.C. April 4, 1989

Mr. Chairman and members of the Committee, thank you for the invitation to testify on automotive fuel economy and the need to increase CAFE standards. The Center for Auto Safety is a non-profit organization that works primarily on consumer issues pertaining to motor vehicles including fuel economy, safety, emissions and fuel quality. The Center has played a leading role in the development of strong CAFE standards under the Energy Policy and Conservation Act of 1975 (EPCA).

The motor vehicle fuel economy standards mandated by Congress in the Energy Policy and Conservation Act (EPCA) represent the most significant energy conservation program in this country. The express purpose of the fuel economy program was to reduce U.S. vulnerability to foreign events by improving vehicle fuel efficiency over 1974 levels by 50% by 1980, and 100% -- to 27.5 MPG -- by 1985. The EPCA fuel economy standards were intended to reduce U.S. oil consumption by 3 million barrels per day (MMB/D) day by 1985.

The Congressionally mandated fuel economy standards are a spectacular success that should be sharply strengthened rather than weakened as has happened over the past five years. The 1989 vehicle fleet will consume 2.5 MMB/D less gasoline than what it would have if the fleet had the same fuel economy as in 1975. To the extent the US is not meeting the 3 MMB/D Congressional goal, it is because (1) there is a 15% shortfall between the mileage new cars actually get on the road and their CAFE ratings and (2) the Department of Transportation (DOT) has failed to set stringent CAFE standrds for light trucks and vans.

On a broader level, the CAFE standards have advanced major national policies. These include enhanced national security through reduced dependence on imported oil; significantly reduced fuel consumption; improved U.S. balance of trade and balance of payments resulting from reduced oil imports; reduced inflationary pressure; lessened dependence of the U.S. economy on foreign petroleum supplies; stimulation of substantial innovation in automotive design and production technology; and helped alleviate the greenhouse effect by reducing carbon dioxide ($CO_2$) emissions. There can be little doubt that the CAFE standards, by decreasing demand for petroleum, have helped break OPEC's ability to fix high oil prices.

Despite the dramatic benefits of the CAFE standards, the Reagan Administration waged regulatory war against stringent CAFE standards and unsuccessfully tried to get Congress to repeal EPCA. These actions include:

* Relaxing the 1986-89 statutory 27.5 MPG CAFE standard for cars;
* Slashing the 1985 and later light-truck CAFE standards;
* Relaxing CAFE test procedures to illegally raise CAFE levels;
* Failing to stringently enforce gas guzzler regulations;
* Decimating DOT's fuel economy program staff so that it can no set and enforce fuel economy standards;
* Reducing the information required from the auto industry which was used to set standards and ensure compliance; and
* Terminating the rulemaking to raise CAFE standards higher than 27.5 MPG for 1986 and later model years.

Under the Reagan Administration, DOT did a complete about face on post-1985 CAFE standards, going from supporting more stringent gas mileage standards beyond 1985 to weakening the 27.5 MPG standard. In January 1981 DOT proposed to raise passenger car CAFE to 41.7 MPG by 1990 and 47.8 by 1995. In an accompanying study entitled Analysis of Post-1985 Fuel Economy, DOT concluded that "we must turn to federal new car energy conservation requirements for the post-1985 period . . . to mitigate continuing dependency on foreign oil." But as a result of DOT's failure to issue more stringent CAFE standards beyond 1985 coupled with relaxation of other CAFE standards, the nation will consume an extra 600,000 barrels/day of gasoline in 1990 due to less stringent gas mileage standards. Since it takes almost two barrels of petroleum to produce a barrel of gasoline, the US must import or produce another 1 MMB/D petroleum to offset the CAFE loss. Besides making the nation more dependent on foreign oil, this empty policy increases air pollution and global warming by emitting an additional 80 million tons of CO2 annually. The increased use of gasoline will produce an extra 100,000 tons of reactive hydrocarbons nationally and 1,500 tons per year in cities such as New York and San Francisco.

## Need to Conserve Energy by Reducing Gasoline Consumption

DOT itself recognizes that oil imports are higher now than when EPCA was passed with 6.35 MMB/D imported in 1988 versus 5.85 MMB/D in 1975. Petroleum consumption for transportation has gone from 8.98 MMB/D in 1975 to 10.47 MMB/D in 1987. DOT recognizes oil imports could go up to 10.5 MMB/D (56%) by 1995 and 11.7 MMB/D (60%) by 2000. Just on energy supply and demand, there is a greater need now than when EPCA was passed to conserve energy by improved fuel efficiency.

One of DOT's primary points in justifying a CAFE relaxation is that vans and light trucks which are increasingly substituted for passenger cars have poorer fuel economy and efforts to increase car CAFE may shift consumers to these vehicles. To the extent this is a problem, the best alternative is to increase the CAFE standards for light trucks and vans which have lagged three to four years behind cars in applying new fuel efficient technology.

## Need to Reduce Gasoline Use and Carbon Dioxide Levels

A major new reason to conserve energy and increase CAFE standards is the "greenhouse effect" -- the build-up of $CO_2$ levels in the atmosphere from combustion of fossil fuels causing a gradual warming of the earth's temperature. At the June 1988 Toronto Conference on the Changing Atmosphere convened by the United Nations Environmental Program and Canada, 300 scientific delegates from 48 nations agreed that $CO_2$ emissions must be reduced 20% in industralized countries by 2005 and 50% worldwide by 2050. Since 30% of all $CO_2$ emissions in the US come from transportation, this goal cannot be attained unless CAFE standards are increased.

## Higher CAFE Standards Save US Jobs

DOT alleges Ford and GM will lose sales and jobs if the CAFE standards are strengthed. Close examination of the results of CAFE relaxations to date show there are no economic hardships for Ford and GM. If anything, relaxation of the CAFE standards allow the domestic auto companies to export small car production and US jobs abroad.

In 1985 when the CAFE standard was 27.5 MPG, GM and Ford sold less than 90,000 "captive imports" -- cars made outside the US and Canada and not counted toward the companies domestic CAFE. In 1984, GM had no imports and Ford had only 1,300. In order to meet the 27.0 and 27.5 MPG CAFE standards for 1984-85, GM and Ford had to produce as many small cars as possible domestically. But with the relaxation of CAFE standards to 26.0 MPG in 1986-88, Ford and GM could pursue a new strategy of making small cars abroad because they were no longer needed for CAFE compliance. Thus by 1988, GM had upped its import sales to 325,000 while Ford had 215,000. For these model years, both Ford and GM could have gained 0.7 MPG in CAFE while creating 175,000 more domestic job if they had made these cars in the US. The table below shows the relation of GM and Ford imports to CAFE standards to date. If CAFE standards are further relaxed or eliminated we project GM and Ford will sell at least one million small cars annually in their import fleet by 1992.

| MY | CAFE Standard | Number Imported Cars<br>Ford | GM |
|---|---|---|---|
| 1984 | 27.0 | 1,300 | -0- |
| 1985 | 27.5* | 15,300 | 74,400 |
| 1986 | 26.0 | 14,700 | 309,000 |
| 1987 | 26.0 | 14,000 | 315,100 |
| 1988 | 26.0 | 215,000 | 325,000 |

* Ford petition to relax 1985 CAFE filed too late to grant under Act.

Unless CAFE standards are increased, the future looks bleak for the American worker. For 1988, GM included the Pontiac LeMans from Korea, Cadillac Allante from Italy plus the Chevrolet Nova, Sprint and Spectrum from Japan in its import fleet.[1] For 1988, Ford had the Merkur from Germany, Festiva from Korea and Tracer from Mexico.

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[1] A vehicle such as the Chevrolet Nova which is assembled in the US is counted in the import fleet if its domestic content is less than 75%. Since the engine and transmission for the Nova are made in Japan, its domestic content is less than 75%.

If CAFE standards were abolished as former DOT Secretary Burnley had recommended, the domestic manufacturers would virtually become importers of everything but large cars given the projected worldwide glut of auto production capacity. The existing Chrysler, Ford and GM ownership of foreign plants and investment interests in foreign car producers position them for full-scale production abroad upon elimination of CAFE standards.

DOT Understimates Manfacturer CAFE

In relaxing the 27.5 MPG CAFE standard the past three years, DOT has set standards lower than what the manufacturers could achieve. As the table below shows, DOT has underestimated Ford and GM's performance from 0.4 to 0.7 MPG in each of these years. This has resulted in a financial windfall of over $500 million to GM and $200 million to Ford in CAFE credits.

| | 1986 | 1987 | 1988 |
|---|---|---|---|
| DOT Rule | 26.0 | 26.0 | 26.0 |
| GM CAFE | 26.6 | 26.7 | 27.6 |
| Ford CAFE | 27.0 | 26.8 | 26.4 |

Since DOT erred in setting the 1986-88 CAFE standards too low, we have an oportunity to judge the Ford and GM allegations that lower gasoline prices and changed consumer demand will not enable them to sell cars at CAFE levels above 26.0 MPG and that they will have to shut down production and lay off workers. Obviously this economic hardship did not occur. Moreover a manufacturer has the option of paying a modest civil penalty as Jaguar, Porsche and Mercedes have done. Mercedes could have met the 26.0 MPG standard by reducing sales of large gasoline models but didn't in order to make a profit on their sales. After all the difference of 1.0 MPG for a manufacturer who fails to meet a standard is simply a penalty of $50 per vehicle. Compared to thousands of dollars in profits on each large vehicle sold, a $50 penalty is clearly the best business decision.

CAFE Can Be Increased By Improved Technology

CAFE can be increased with improved technology and without restricting consumer choice in the market place. The 1981 DOT "Analysis of Post-1985 Fuel Economy" projected a 48 MPG 1985 CAFE based on improvements in technology without restricting large car sales. Some of the better technologies include improved transmissions such as the continuously variable one on the Subaru Justy, multi-valve engines, better materials, and direct injection diesels.

Both performance and fuel economy can be improved with the use of 4-valve per cylinder (4-v/c) engines which can improve fuel economy by 20-25% while decreasing acceleration time. DOE has pointed out that the 1988 Pontiac Grand Am with the 4-v/c Quad 4 engine got 22.4% better fuel economy than the four pound lighter V-6 Chevrolet Beretta while doing 0-60 mph a half-second faster.

Another example of how a 4-valve engine outperforms a 2-valve engine is shown in the comparison of the 1988 Toyota Camry to the Ford Tempo on the following page. The 4-valve Camry is nearly 100 pounds heavier than the Tempo but gets 21% better fuel economy and does 0-60 a full 1.6 seconds faster than the Tempo (9.2 to 10.8). Toyota has found this technology so impressive that all its 1988 models were 3 or 4 valves per cylinder.

## Higher CAFE Standards for 1991-2001

The question for CAFE is not whether CAFE should be increased but by how much. An increase to 34 MPG is a modest increase that simply prevents further backsliding by manufacturers from what they project the market will yield. The Center has proposed to DOT that CAFE standards for cars be doubled to 55 MPG by the year 2001 and that comensurate CAFE improvement standards be set for light trucks and vans. These higher CAFE standards are needed to conserve energy, reduce $CO_2$ emissions, and reduce the export of small car production and American jobs abroad.

## TABLE

## BENEFITS OF 4-VALVE PER CYLINDER TECHNOLOGY

| | 1988 Toyota Camry | 1988 Ford Tempo | Change%* Camry to Tempo |
|---|---|---|---|
| Curb weight | 2810 lb | 2721 lb. | -4 |
| Engine size | 122 cu. in. | 140 cu. in. | +15 |
| Camshaft | DOHC | OHV | -- |
| Valves/cylinder | 4 | 2 | -- |
| Output power | 115 HP @ 5200 RPM | 100 HP @ 4400 RPM | -15 |
| Torque | 125 ft.lb @ 4400 RPM | 130 ft.lb @ 2600 RPM | +4 |
| Interior volume | 89 cu. ft. | 90 cu. ft. | ~0 |
| Trunk volume | 12 cu. ft. | 13 cu. ft. | +8 |
| Transmission type | * 5-spd. manual | 5-spd. manual | -- |
| Axle ratio | 3.74 | 3.73 | ~0 |
| _Performance_ (seconds) | | | |
| 0-30 mph | 2.9 | 3.3 | +14 |
| 0-60 mph | 9.2 | 10.8 | +17 |
| 0-¼ mile | 17.0 | 17.8 | +5 |
| 30-50 mph (top gear) | 14.2 | 14.6 | +3 |
| 50-70 mph (top gear) | 16.2 | 15.3 | -7 |
| _Fuel economy_ (mpg) | | | |
| EPA city | 28.8 | 23.1 | -20 |
| EPA highway | 41.7 | 36.3 | -12 |
| EPA combined | 33.3 | 27.6 | -17 |

Source: "Car and Driver" and "EPA 1988 Test Car List."

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* Ford Tempo/Toyota Camry characteristics.

Senator METZENBAUM. Thank you very much.

Our next and last witness is Mr. Charles Ebinger. Mr. Ebinger, we are happy to have you with us. Would you, just as a prefatory statement, indicate to me—I know you are in the consulting field. For what kinds of groups do you consult? For governments, private enterprise?

## STATEMENT OF CHARLES K. EBINGER, GROUP MANAGER, ENERGY ANALYSIS, INTERNATIONAL RESOURCES GROUP, LTD.

Mr. EBINGER. I'll answer that question in a minute, Mr. Chairman. Let me apologize first for the confusion. I was asked here to testify in another capacity I have which is as a senior fellow at the Center for Strategic and International Studies here in Washington, a nonprofit organization that I have been affiliated with since 1979.

In answer to your question, Mr. Chairman, as a private consultant, I consult to people in the oil, gas, electric power, alternative and alcohol fuels.

I'm delighted to have the opportunity, Mr. Chairman, to meet once again with the committee to provide an overview of the world petroleum market to serve as a backdrop for your hearings on the proper role of CAFE standards in the future evolution of U.S. energy policy.

Mr. Chairman, the reality of the U.S. energy situation in my view is that while the last administration relied on the wisdom of the marketplace and the American people for over eight years benefited from the lowest home heating oil and gasoline prices since 1973, U.S. energy security has substantially deteriorated.

In January 1989, two milestone events occurred. For the first time in 44 years, the United States imported more oil than we produced domestically, and oil production in the State of Texas hit the lowest level in 45 years.

Since 1986 and the fall in oil prices, domestic crude oil production has fallen by another nearly 600,000 barrels a day and based on projections by the Energy Information Administration, by near the end of the first Bush Administration, we will see domestic production fall nearly another million and a half barrels a day, a very sobering figure when we consider the kinds of energy savings we are considering against improvements in the CAFE standards.

In response to low oil prices, American consumers are today using the highest level of petroleum products that they have since 1980. And if this trend continues, we will see our imports rise to very dangerous levels.

I believe the committee staff have prepared a graphic demonstration of how our oil imports, after falling from nearly 9 million barrels a day in 1977 to 5 million barrels a day in 1985 with the prodigious development of coal, nuclear energy, natural gas, conservation and alternative energy, we have in the last several years reversed that trend. And as Senator Nickles knows well coming from an oil producing state, we are now dangerously approaching the 50 percent threshold of our oil imports.

Even at today's relatively low average OPEC prices of $18 per barrel, each million barrels a day of incremental imports adds $6 billion to the Nation's trade bill, and if oil prices were to rise simply to $21 a barrel, hardly a huge figure in light of historic events, the administration and the Congress might confront an additional oil import bill of an additional $50 billion within the next few years.

Mr. Chairman, while our rising dependency on imported petroleum has received some attention in the national media, little attention has been paid to the fact that in the refinery sector in 1988 our distillation capacity was at a near record 92 percent utilization which effectively means that we have no surplus capacity in this country to produce additional volumes of gasoline and aviation fuel. And this is vital because I think we have seen now with the loss of Alaskan crude production, given the tragic events in Alaska, how volatile the gasoline market can be to both exterior events in our own country as well as those emanating from abroad.

It is important as we countenance the newer pending environmental regulations on gasoline volatility, desulphurization of diesel fuel and so forth, as Mr. Ditlow highlighted in some of his testimony, that the impact of these, whether for good reasons or ill, will be to reduce U.S. refinery capacity as some refineries are unable to meet these standards, and this will lead to a sizable addition of petroleum product imports in addition to crude oil imports.

Before moving from the petroleum sector, Mr. Chairman, I would just like to highlight—again, I think we have a graphic here showing this—that today the reality of the world petroleum market is that OPEC controls some 82 to 83 percent of proven oil reserves and that they possess 85 percent of the surplus capacity to produce oil that exists in the world today.

I have been deeply disturbed listening to some of the commentary on the national news media in wake of the events in Alaska suggesting that we don't need Alaskan oil because we can get this oil from Mexico, Venezuela and elsewhere outside the volatile area of the Persian Gulf, and I would simply suggest nothing could be farther from reality. The reality today is that as world demand for oil is rising by nearly 1 million barrels a day, this oil is increasingly coming from the Persian Gulf, the precise area that we have seen disrupted twice in the last 15 or so years.

Mr. Chairman, as you proceed with your examination of CAFE standards, I would urge strongly that several key facts be kept clearly in mind, and this is the fact that U.S. oil production continues to fall in the lower 48 states in response to the low prices we have seen in the last few years, and the fact that production at the existing Prudhoe Bay facilities in Alaska has peaked. In the absence of new discoveries in Alaska at Prudhoe or ANWR, if we open the Arctic National Wildlife Refuge, or elsewhere near the existing pipeline, the vital contribution that Alaskan oil could make could well cease. And without any oil from Alaska and oil prices even where they are today, we would have to import an additional $10 billion more of oil every year.

As the Reagan Administration's report Energy Security in March 1987 reminded us, 67 percent of the oil we consume in this Nation occurs in the transportation sector in our cars, our trucks, our airplanes. Thus, if we do not continue to erode our Nation's dependence on oil in the transportation sector, we will have nothing but the strategic petroleum reserve and draconian regulatory measures to rely upon in a future crisis.

There are clearly several ways to reduce the use of oil in the transport sector in addition to CAFE. We could reduce consumption through a higher gasoline tax, but this is opposed by most consumers. We could lower the speed limit, a policy reversed by the Reagan Administration and politically unpopular. And we can develop alternative transportation fuels. But we must realize that each of these options has obstacles. None of these will succeed in fundamentally reversing the dramatic change that has occurred in the production sector of our industry.

In the interest of time, Mr. Chairman, let me just summarize that the bulk of the rest of my testimony goes into major concerns I have in the electric power and natural gas area suggesting that a lot of the assumptions, namely, that electricity growth will remain small, that this is not true, that we are beginning to see electricity growth go through the roof.

We are beginning to see the undoing of the successes we have had backing out oil in that sector with oil beginning to repenetrate that sector. And if I am correct and OPEC sees the obvious trends and lowers the price of oil, I think we may well see oil, unfortunately, repenetrate that sector in a big way.

In addition, I believe that OPEC will hold the price of oil at a level that makes many of the rosy assumptions about natural gas come out to be injurious, and this will have major implications for the citizens of Ohio and other states that have tremendous reliance on natural gas.

Let me conclude then by saying that we are at a difficult time in our energy policy. I was personally distressed to hear that we are going to have another four or five months before we have enunciation of a new national energy policy. Within that time, we may well see the production sector of this country drop by another 400,000 to 500,000 barrels a day, imports rise, further deteriorating the Nation's trade imbalance. And I would urge the Chairman that in this examination of CAFE standards, that we realize if we do not move on the transportation sector, we cannot and will not have a coherent national energy policy.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Ebinger follows:]

*U.S. ENERGY POLICY AT THE CROSSROADS*

# TESTIMONY BEFORE THE
# SUBCOMMITTEE ON REGULATION AND CONSERVATION
# COMMITTEE ON ENERGY AND NATURAL RESOURCES
# U.S. SENATE

*Hearing on Automobile Fuel Efficiency Standards*

By

Charles K. Ebinger
Group Manager, Energy Analysis
International Resources Group, Ltd.

April 4, 1989
Washington, D.C.

Good Morning, Mr. Chairman

I am delighted to have the opportunity to meet with the Committee and to provide an overview of the world petroleum market to serve as a backdrop for your hearings on the proper role of CAFE standards in the future evolution of U.S. energy policy.

I believe that these hearings are particularly timely given both the recent tragic oil spill in Prince William Sound in Alaska which temporarily closed nearly one-quarter of U.S. domestic oil production and the fact that just last week the nation experienced the tenth anniversary of the nuclear accident at Three Mile Island. Since 1979, the United States has not received an order for a new grass roots nuclear power plant. While nuclear energy's contribution to the nation's energy balance since that time has continued to grow to around 20% of the nation's electricity consumption and has backed out nearly 876 mbd of imported oil, the reality today is that in the absence of massive regulatory reform to alleviate the bottlenecks on non-fossil fuel oil use in the electricity sector, we as a nation will run the risk of undoing the hard earned accomplishments of the last decade; namely, a massive reduction in the level of oil imports.

Mr. Chairman, the reality of the U.S. energy situation is that while the last administration relied on the wisdom of the marketplace and the American people benefited from the lowest home heating oil and gasoline prices since 1973, U.S. energy security deteriorated.

Consider the following statistics in our nation's energy situation that have occurred since OPEC collapsed the price of oil in 1986.

- o Domestic crude oil production has cascaded from 8.68 mmbd to 8.1 mmbd in 1988. On the basis of current trends, by 1993 U.S. crude oil production will drop an additional 1.5 mmbd.
- o Low oil prices have simultaneously raised total U.S. oil consumption from 16.29 mmbd in 1986 to 17.01 mmbd in 1988, the highest level since 1980. The EIA projects that by 1993 oil demand will hover around 18.4 mmbd.
- o This combination of rising petroleum demand (930 mbd), combined with falling domestic production (500 mbd), has led to skyrocketing oil imports.

| | U.S. Oil Imports (Gross mmbd) | % of Consumption |
|---|---|---|
| 1985 | 5.0 | 28.0% |
| 1986 | 6.2 | 38.2% |
| 1987 | 6.67 | 40.0% |
| 1988 | 7.08 | 41.6% |
| 1989 | 7.64 est | 44.0% |
| 1993 | 10.29 est | 55.9% |

- Even at today's relatively low oil prices -- $18/bbl (average OPEC) -- each 1 mmbd of incremental imports adds $6.15 billion to the nation's trade deficit.

The serious deterioration in the nation's trade deficit arising from rising volumes of oil imports has been masked by low oil prices. In 1987, the cost of U.S. oil imports averaged $18.12/bbl, while in 1988 it averaged $15.29. If oil imports reach 9.8 mmbd, as forecast by the EIA, by the end of the first Bush Administration the cost of these imports will be $64.4 billion at $18/bbl, at $21/bbl the cost would be $78 billion. In 1988, the U.S. oil import bill was about $42 billion.

Mr. Chairman, the situation confronting the domestic oil industry is rapidly becoming dangerous to the economic welfare of the nation and to U.S. national security. Since 1986, thousands of workers in the oil field and/or service industries have lost their jobs and many out of desperation have left the industry, they may not be available if needed.

The deterioration in the industry is exhibited by the following statistics.

| | | |
|---|---|---|
| Well Completions | 1981 | 89,234 |
| | 1987 | 34,927 |
| | 1988 | 24,500 |
| Exploratory Wells | 1981 | 17,430 |
| | 1987 | 5,610 |
| | 1988 | 5,350 |

While many analysts disagree with the concerns expressed above and believe that the existence of 550 million barrels in the Strategic Petroleum Reserve ensures our short-term energy security, I would like to point out to the Committee that in terms of days of imported supply, the SPR fill rate is not keeping up with rising dependency on imported crude oil and petroleum products. This is particularly alarming in view of the fact that in January 1989 two milestone events occurred. For the first time in 44 years, the level of imports exceeded domestic production; Texas oil production fell to the lowest level in 45 years.

Mr. Chairman, while our rising dependency on imported petroleum has received some attention in the national media, little attention has been paid to the fact that in the refinery sector in 1988, distillation capacity, when adjusted for non-operating refineries, was at a near record 92% utilization -- meaning that there is no idled refinery capacity, especially for light petroleum products -- such as gasoline and aviation fuel -- so vital in the event of a national emergency.

I strongly dissent with the view of some analysts that this issue is not of concern to U.S. national security since U.S. gasoline demand has peaked. I do not think it has peaked and share the view of First Boston that it will grow about 1.3% per annum over the next five years owing to further penetration of the transportation market by light trucks.

The reality of the U.S. refinery situation today is that it is extremely unlikely that any major new grass roots refinery will be built in the United States, owing to environmental and other regulatory costs that make construction of a refinery uncompetitive with refineries built elsewhere. While significant spare refinery capacity overseas continues to exist, our nation's failure to rectify this situation means that as petroleum product demand continues to rise it will be met by imports.

In this regard, it is important to note that new or pending environmental regulations on gasoline volatility, desulphurization of diesel fuel, etc. will further reduce U.S. refinery capacity as some refineries are unable to meet these standards. At the same time, demand for premium cleaner fuels will increase crude oil demand since it takes more crude to make these fuels, thus exacerbating the import situation. I do not mean to suggest that some of these regulations are not needed given concerns about ozone depletion and the greenhouse effect, but we should realize that actions taken in one area may create problems in other arenas.

My chief concerns about the inadequacy of U.S. refinery capacity are:

1. that rising volumes of petroleum product imports will further exacerbate our trade deficit; and

2. that if we had to mobilize our civilian and military economy for a significant national emergency, we might experience major logistical difficulties.

Finally, before leaving the petroleum sector, I would like to highlight several facts for the Committee.

- Today OPEC controls 82% of proven oil reserves and possesses 85% of global surplus productive capacity. *Despite claims during the recent Alaskan oil spill that closing down Alaskan oil production would not threaten U.S. national security because the U.S. could buy more oil from Mexico, Venezuela, the North Sea, etc. and not from the Persian Gulf, nothing could be further from reality. There is no surplus capacity in Mexico.* Furthermore, it is important to remember that ~~the~~ average cost of Persian Gulf crude is $1-2/bbl, far below U.S. costs.

- Oil production in the Middle East rose by 15% in 1988 and represents 23.6% of global production.

- OPEC production rose 11.5% to 32.5% of world production.

- With free world oil consumption at 50.2 mmbd, this means that even at 2% annual growth, world consumption will grow in excess of 1 mmbd/year. An overwhelming percentage of this oil will come from OPEC, especially the Middle East; where twice in the last sixteen years political events have sent the oil market into turmoil. In addition, the area remains a powder key, given the ongoing turmoil in Iran, the ongoing stalemate of the Arab-Israeli dispute and new concerns about Iraq acquiring a nuclear weapon.

Mr. Chairman, as you proceed with your examination of CAFE standards, several facts should be kept clearly in mind.

o U.S. oil production continues to fall in the lower 48 states and production at Prudhoe Bay in Alaska has peaked. In the absence of new discoveries in Alaska at Prudhoe, ANWR or elsewhere near the existing pipeline, the vital contribution that Alaskan oil makes to U.S. oil production will cease. Without any oil from Alaska and oil prices at $18/bbl, the U.S. will have to import $10 billion worth of more oil every year.

o As the Reagan Administration's report Energy Security (March 1987) reminded us, 67% of U.S. oil consumption occurs in the nation's cars, trucks and airplanes. Thus, if we do not continue to erode our nation's dependence on oil in the transportation sector, we will have nothing but the SPR and draconian regulatory measures to rely upon in a future crisis.

o There are several ways to reduce the use of oil in the transportation sector.

-- extend CAFE standards
-- reduce consumption through a much higher gasoline tax
-- lower the speed limit
-- develop Alternative Transportation Fuels

*Clearly, each of these choices entails real costs and none of them will change things quickly. They also represent interference in the marketplace. One thing is certain, however, if we close down domestic oil and gas production by denying access to potentially oil rich areas, we will have to adopt one or more of the above policies if we believe that there is some level of oil imports that is dangerous to U.S. national security. Despite U.S. government findings in 1987 and early 1989 that U.S. energy security is endangered by the events of recent years and future prospective trends, the nation remains paralyzed by inaction.*

Mr. Chairman, the events occurring in the petroleum sector would be alarming enough even in isolation, but other sectors of our energy economy are also in danger. Nowhere is this more true than in the electric power sector.

As a result of energy conservation induced by the unforeseen oil price shocks of the 1970s and early 1980s, many utilities found that large scale coal and nuclear plants begun in the 1960s and early 1970s to meet anticipated demand growth of 6-7% per annum were not needed when these plants came on line in the late 1970s or 1980s. The fact that these plants were not needed led to regulatory challenges as to the ability of the utilities to pass on the cost to consumers, etc. These events occurred in concert with the passage in 1978 of the Public Utilities Regulatory Policy Act (PURPA) which created a new independent power industry with complex regulatory guidelines under which many utilities had to buy PURPA power even if they had idled conventional facilities. The clear intent of PURPA under the Energy Security Act was to encourage non-fossil fuel power.

The financial difficulties that many utilities have encountered with idled, partially completed, or scrapped coal and nuclear power plants led to a burgeoning perception in the federal government, state PUCs and even in some utilities that surplus electricity capacity would be available well into the 1990s and that load growth would average only 1-2% per annum through the year 2000. Some utilities adopted this view to avoid regulatory hassles while those which believed they needed new capacity embarked on policies of buying power from independent power producers from other utilities with surplus capacity, or by building plants that could be completed quickly. With the rescinding of the Fuel Use Act, utilities rushed to utilize natural gas in cogeneration and in combined cycle plants. To a lesser extent, oil began to re-penetrate the electric power sector.

Mr. Chairman, it is ironic given these events to recall that at our height we used 1.7 mmbd of oil in the electricity sector. This was reduced overwhelmingly by 1985 to about 400 mbd, as a result of the development of nuclear plants (876 mbdoe), coal and conservation. On a global basis, it is surprising that the critics of nuclear power fail to note that since 1979 nuclear power has reduced the demand for OPEC oil by 4 mmbd. It is important that as we observe the 10th anniversary of the accident at Three Mile Island -- in which no individual was killed and yet which has led to a ten year hiatus in the construction of any new grass roots nuclear plants in the United States -- we remember that nuclear energy since 1979 has saved U.S. consumers billions of dollars in oil imports and will continue to do so for years to come.

Mr. Chairman, I must confess that I fear that ten years from now the accident in Prince William Sound will be seen as the death knell of the U.S. domestic oil industry as a result of well intentioned but excessive environmental zeal. For the security interests of the nation, we must at this critical time allow reason and thoughtful contemplation to govern any policy decisions taken as a result of this tragic accident.

The perception that electricity will be in surplus for the foreseeable future has been shattered by recent events. Despite forecasts of 1-2% demand growth per annum, since 1985 demand has grown in excess of 3% per annum ; in 1988 it rose by 5%, hitting levels in some parts of the country not expected before the 1990s. While some areas of the country continue to have surplus capacity, major areas of the country have declining or nonexistent surplus capacity.

With new grass roots nuclear plants on hold pending major regulatory reform and growing concern about coal's contribution to the greenhouse effect, further regulatory constraints on coal will place much of the nation's future economic health on the continued availability of low cost natural gas and oil and conservation. While conservation will play a vital role, continued gains in end use efficiency and alternative energy development have been severely eroded since the oil price collapse in 1986 and the erosion of federal and state tax credits.

Mr. Chairman, over the last two years there have been a plethora of excellent studies heralding gas as the preferred fuel for the nation's energy future. Natural gas has many attributes. It is clean burning; it contributes less to greenhouse concerns than oil or coal; and gas combined cycle plants can be built quickly with high operating efficiencies.

I want to make it clear that I do not disagree that natural gas may be an abundant resource at prices at the wellhead of between $3-4/MCF, as cited in many of these recent reports. What I worry about is that oil prices will remain at levels for the foreseeable future that hold down natural gas prices or, alternatively, that natural gas prices will disconnect from oil prices following the end of the gas bubble. If this occurs, prices for captive customers in the residential and commercial markets could rise significantly.

In the last two years (1986 - 1988), in response to low prices and soaring utility and industrial demand, natural gas consumption has risen by 11%, the largest two year gain since 1970. In 1987, U.S. domestic proven natural gas reserves fell for the sixth straight year to 153.9 TCF from 162.9 TCF in 1985 and 158.9 TCF in 1986. Reserve additions in 1987 equalled only 45% of domestic production. In 1988, gas curtailments occurred in six states.

The Energy Information Administration estimates that natural gas demand in the electricity sector will double from 3.2 TCF in 1988 to 6.2 TCF by 2000. In terms of gas deliverability, Goldman Sachs stated in a recent report that while there was a surplus relative to demand of 340 BCF in 1988, relative to demand this will become a deficit of 60 BCF by 1990.

Mr. Chairman, many analysts of the gas market cite the figures of the Potential Gas Committee as evidence of the future role that gas can plan in the economy.

Potential Gas Committee

983.4 TCF of Gas Reserves Remaining

| | |
|---|---|
| 164.5 | Current Production |
| 238.5 | New Fields |
| 184.95 | Speculative Frontier |
| 90.1 | Coal Bed Methane |
| 118.55 | Alaska |
| 187 | Proven |

What these analysts fail to note is that the key as to whether or not these reserves are developed is the link between oil and gas and gas and coal prices in the absence of federal policies overtly favoring gas on environmental or other grounds.

If regulatory constraints continue on nuclear energy and accelerate on coal, if gas production remains sluggish because of low oil prices, and if electricity demand continues to rise, we will not have massive power shortages as forecast by some analysts. Rather, we will use more imported oil as long as OPEC has the wisdom to keep the price of oil below the price of competitive fuels. Oil will first penetrate the idled plants in the industrial boiler and electricity markets that have been backed out by coal and nuclear power (1.3 mmbd), then new facilities will be built. These developments, if they occur, will increase the degree of our import dependency on imported oil above the levels cited earlier in my testimony.

Finally, there is one major "sleeper" issue that could have a major deleterious impact on our energy situation. In both the March 1987 Energy Security Report and in the Department of Commerce's response to the Enserch-led Section 232 petition, forecasts of future oil supply and demand by the year 2000 assume an average fuel economy standard of 34 miles per gallon. If this goal is not reached, demand for imported oil could be 500 mbd higher than projected. This fact suggests that if the Committee decides not to raise CAFE standards, then there is little prospect that we will sizably reduce the projected levels of our oil import dependency from the Persian Gulf, in the absence of massive changes elsewhere in our energy economy.

## SUMMARY

Mr. Chairman, the energy situation confronting the nation demonstrates the dangers of piecemeal energy, environmental and regulatory policies that continue to bedevil the implementation of a coherent national energy policy.

As noted earlier in my testimony, the key issue confronting us is the answer to the question of whether there is an oil import level that is dangerous to U.S. national security. If there is, and many good analysts dispute my contention, then we have to ask how we can stem the tide.

In the course of this debate, policies in the transportation sector must be a major focus of policy formulation. But the issues do not stop there. The oil spill in Alaska demonstrates the ongoing difficulty of reconciling major diverse policy goals, e.g. having safe, secure energy supplies while protecting the environment. Recent events will further polarize the debate over onshore and offshore oil and gas leasing in sensitive areas in California, Florida, and Alaska, especially in ANWR.

In the electricity sector, we need to decide how to meet soaring electricity demand. If we foreclose some options, let us do so only after thorough examination of the implications of our actions on other key energy and environmental concerns. We need to look at how regulatory policies such as PURPA can be perverted in a Humpty Dumpty like fashion to allow greater utilization of oil and gas. We need to address the difficult choices that we may confront if predictions of the dangers of global warming are borne out. The contribution that nuclear energy can play in meeting greenhouse concerns will only occur if the American people make choices unpalatable to the critics of nuclear power.

**We need to address how we can best balance short-term consumer versus broader long-term national interests. We need to reconcile the diverse energy interests of different regions of the country.**

**Finally, we need to ask: if the U.S. subsidizes certain fuels, what are the implications for the competitiveness of our trading position in the international arena?**

**Thank you, Mr. Chairman, for having this opportunity to share these thoughts with the Committee. I will be delighted to take questions.**

Senator METZENBAUM. Thank you very much.

Dr. Whitman, President Reagan has officially declared oil imports to be a threat to the national security. In view of that, what is GM's view as to the need for efficiency in petroleum consumption? And it brings back to my mind a famous statement of Charles Wilson: What's good for General Motors is good for the country. And I'm wondering whether or not General Motors in this situation is in an exactly opposite position to that which has been stated by so many others today, as well as by former President Reagan.

Dr. WHITMAN. Just for the sake of historical accuracy, Senator, I have to point out that Mr. Wilson's statement was, in fact, what is good for the—it's the other way around. What is good for the country is good for General Motors.

Senator METZENBAUM. That's not the way I ever heard it or the American people.

Dr. WHITMAN. I know it was reversed early on, and it has been impossible to get the accurate statement back.

Senator METZENBAUM. It has a life of its own.

Dr. WHITMAN. It's a nice myth, but in any case, that, I believe, is the historical record of what he said.

To come back to your question about energy security, the single most important aspect of energy security, Senator, it is my belief is our ability to respond very short term to sharp disruptions in world energy markets which is, of course, what occurred in the first and second OPEC oil shocks. And that ability to respond quickly and responsively and without enormous cost to the economy to sharp disruptions depends not really on the level of energy consumption ongoing, whatever it is, but on first of all having diversified sources of supply that one can turn to when one particular source is disrupted, and secondly, to having some kind of immediate buffer as we have today in the strategic petroleum reserve.

Unfortunately, however much we would like it, having a variation of 5 or 10 percent up or down in our ongoing consumption or even our ongoing level of imports of petroleum would have very little impact on our ability to respond in the case of a sudden and severe disruption.

Senator METZENBAUM. You were here when I spoke earlier in my opening statement about the amount of petroleum we could save if we had better efficiency standards as compared to the loss up in Valdez. And your comment just now in response to my question is that it depends upon our ability to respond promptly. The Valdez tanker has the mishap, and obviously we don't respond with one exception. The exception is that the oil companies of this country are gouging the American people for billions of dollars for no reason whatsoever. Some oil companies have no relationship to what is going on up in Valdez, but they just thought it was a great opportunity to do it.

Now, what concerns me is that if we lower the demand, if we lower the amount of consumption, we aren't going to solve that problem completely, but it seems to me that the lesser amount of gasoline consumed in this country, the better able we are to respond to eventualities such as the Shah of Iran resigning—I mean being deposed, or a Valdez situation or whatever the case may be.

And what bothers me is that the number one corporation in America is not on the team. The number one corporation in America is here saying to us don't raise the standards. We can do it, but it will cause imports. And yet, the facts are—you make a very good case out—that isn't true at all. I mean, that is somewhat of a fiction because we have put in place the standards over the past several years, number of years since the Carter Administration, and that wasn't the reason that we lost car sales to the foreign car makers. Realistically speaking, they were making better cars than you were making and that Ford was making and that Chrysler was making. And when you started to accommodate and recognize that need, you at least held your own more recently than you did in the past and when we also put in the voluntary restraints.

So, it seems to me that General Motors and Ford and Chrysler owe the Nation a little bit more effort than I see with this total resistance on the CAFE standards and the political pressure that was placed on the Reagan Administration to reduce it from 27 and a half to 26 and a half, and I gather it is still taking place today because these men who were here from the Department of Transportation tell us that they are still considering the rule of reducing it from 27 and a half to 26 and a half.

Now, I have made a speech, but I guess it's because I feel strongly about it and feel disappointed that these major automobile manufacturers aren't working with us but rather, as I see it, are here in opposition.

Dr. WHITMAN. Several comments, Senator. One is that both the independent research by completely—by researchers who have nothing to do with our industry and our own experience indicate clearly and conclusively that what led to the great increases in fuel economy over the period since 1973 was not CAFE but simply changes in actual and perceived gasoline prices, as well as concerns about energy availability.

Senator METZENBAUM. You don't think CAFE had anything to do with your increasing the mileage efficiency?

Dr. WHITMAN. I do not.

Senator METZENBAUM. You do not.

Dr. WHITMAN. No. I think——

Senator METZENBAUM. Well, how do you account for the fact that it went up so dramatically since we put those standards in and it wasn't going up dramatically before that?

Dr. WHITMAN. Well, in fact, GM's vast investments in increased fuel economy began several years before the fuel economy standards went into effect. Although because of the lead times involved in the automobile industry, those vehicles did not begin to actually come out into the marketplace until several years after we began to make the investments.

And you talk about our not being on the team, but in fact we made investments of over $40 billion in the modernization of both plant and product and a great deal of that was related specifically to the efforts to produce—to down-size, move to front-wheel drive, which was the single greatest technological change that occurred to bring about this vast increase in fuel efficiency which you have referred to often and which, indeed, we are very proud that we were able to do.

Although I must say that one of the things that concerns me here this morning is the assumption that somehow one can simply extrapolate linearly forever into the future, and that because these very large improvements were possible, that somehow by magic fiat we can do it again.

Senator METZENBAUM. Well, Henry Ford said when he testified before us four years ago that it was government's imposition of the CAFE standards that helped the industry move to the point of better fuel efficiency.

Dr. WHITMAN. I have not seen, Senator—and I have spent my life as a professional economist—any serious study which has produced that result. I would be glad to take a look at anything anybody has that says that, but as I say, the studies I have see indicate the opposite.

Now, clearly in the last year or two, the CAFE rules have become binding because CAFE has been going in one direction and energy prices have been going in another. That has created problems certainly for the domestic producers in meeting those standards. But again, the major result, as far as we can see, has been to shift the consumer around the marketplace among manufacturers to the detriment of U.S. producers without necessarily leading to any increases in what is actually bought and driven.

Senator METZENBAUM. Mrs. Petrauskas, I commend you for including in your testimony some guidelines for increasing CAFE. Should we choose to do that, would you and other Ford management people work with my staff on this to develop the most effective and least burdensome CAFE?

Mrs. PETRAUSKAS. If I just may say, Mr. Chairman, we are prepared and we would look forward to working in any kind of a private and public sector setting to do some, we believe, very important fact finding in terms of the extent to which the fuel economy of vehicles can be improved and what that means in terms of the various goals that this committee is addressing.

The one thing I would want to underscore is that our plea to the committee is to do several things. One is to look at what kind of an approach we might have where the goal that is set for an automotive producer is targeted on those things that we have control over, namely, the technology that we apply to particular models as opposed to the mix of vehicles that under any given set of circumstances might be sold.

And then secondly, the plea that we think through what role there is for alternative fuel vehicles, that is, substitutes for petroleum derived vehicles.

Senator METZENBAUM. Do I understand your answer to be yes?

Mrs. PETRAUSKAS. My answer is yes in terms of fuel economy improvement, Mr. Chairman. It is no if the narrow question is a corporate average approach. Our plea to the committee is to look at alternatives.

Senator METZENBAUM. Well, let me say this to both Ford and General Motors and Chrysler who is not represented, although they were invited. There are many of us in the Congress who are going to move on this subject. We will introduce legislation shortly to increase the CAFE standards. My view is that legislation is always better developed when those affected work with the legislators in attempting to develop it regardless of whether or not they approve of the basic thrust.

And so, I just want to say to you that our door is open to you if you wish to participate in the process. But if you just prefer to take the position that you will attempt to defeat us on the floor and see if you can get more votes than we can, of course, that's your privilege.

But I would say to you that I would respect your right to attempt to do that, but we still would welcome any input that you might have because we want to be reasonable. We want you to succeed economically and we want the American people to buy American cars.

But we do have concerns on CAFE. We do have concerns about global warming. We do have concerns about oil imports, and we are going to take some steps in an effort to move in this area. This is no secret that this committee on a vote voted 9 to 9 about adding it to the ANWR bill, and one member of the committee made it quite clear that he was supportive, but felt that the issue belonged in another committee of which he is a member and didn't belong here.

That being the case, I think we do have the votes in Congress to move to increasing CAFE standards. I feel rather strongly about that—I mean strongly about the fact that we have the votes, not strongly about the support for the legislation. And I feel optimistic, but we would like to work with you.

Dr. **WHITMAN**. May I respond very briefly, Mr. Chairman, and that is I very much appreciate those comments and we agree, of course, that we would like to see, obviously, the best actions taken and that is likely—that if the companies who make the vehicles can have their concerns heard, that would be, we feel, likely to lead to better results.

But let me just say that the source of our concern, obviously, is not the desire to be adversarial. It is not a lack of concern with conservation or with the many serious questions that have been raised. But the way the CAFE standards operate is to force us to try to move in two completely opposite directions at once. One is what is in the direction of customer satisfaction, of meeting the needs and the demands of the customers in the marketplace. The other is meeting the legislative or regulatory requirements growing out of the legislation.

Inevitably, if we are forced to try to move in both directions at once, we will be at a competitive disadvantage and, therefore, the American workers will be disadvantaged as compared to other manufacturers who for historical reasons are not forced as tightly as we are to try to move in exactly opposite directions. And it is that concern that underlies everything we say and the positions we take, that we cannot go north and south at the same time.

Senator **METZENBAUM**. No, but I think that you very well might be able to come up with some ideas that would not be an injustice to your own corporations while recognizing the congressional will that I believe is there.

For example, I think it is an absurdity—and this Senator is going to try to figure out a way to do something about the fact that you can import as many Jaguars and Mercedes and Rolls—and I forget the name of some of those fancy Italian cars—that are coming into this country. And nobody pays any attention to the fact of CAFE standards because whatever the penalty is, they are willing to pay it. But meanwhile, if you buy a Jag, you don't buy a Cadillac, you don't buy a Lincoln. And I think it's an issue that we have to give some attention to to figure out what we can do about it.

I'll never forget when I was involved in this very issue many years ago during the Carter Administration, and I got a call asking me if I wouldn't be good enough to make an exception for the Rolls Royces so that they wouldn't have to conform. I thought that was rather ludicrous for 10 different reasons, and so I obviously said no.

But we are willing to work with you. If you have any inclination to do so, I think the time is now because our timetable is now.

Senator Nickles, who has been very patient, has not indicated what his timetable is, but I know darned well that it also is now, and so I turn the floor over to you. [Laughter.]

Senator NICKLES. Mr. Chairman, thank you.

I would like to ask our witnesses, Mrs. Petrauskas and also Dr. Whitman, what the impact would be on Ford and on GM if Congress did pass Senator Metzenbaum's bill or amendment, whichever it may be, to increase the CAFE, to mandate the CAFE standards be 34 by what? The year 2000. What impact would that mean?

Dr. Whitman, I believe you said that right now presently 13 percent of the automobiles now produced by GM would meet that standard. All those are the compact cars. Is that correct?

Dr. WHITMAN. The what?

Senator METZENBAUM. Compact.

Dr. WHITMAN. Oh, the compact. No, I believe Helen Petrauskas made that comment.

Mrs. PETRAUSKAS. That was in our testimony trying to provide some measure of what a 34 average standard means.

I think there are two other ways to look at it, and I'd like to underscore those.

When we look at the studies that recommend or discuss significantly higher average fuel economy numbers, they all have one fundamental fact in common and that is they rely on work that was done in the late 1970s and early 1980s to see how far we could take diesel technology. Well, we have learned a lot since that time, and one of the things we have learned is that customer acceptance for diesel—diesels in passenger cars in the United States has not been very good.

So, the question that these higher levels beg is what is it that is going to be different about tomorrow that is going to make large numbers of very small vehicles equipped with diesel engines satisfy the transportation needs of this country when they haven't in the past.

Senator NICKLES. I understand. I'm trying to get some kind of idea of what it would mean to Ford, what it would mean to GM if we had those mandates. And you have to have some kind of assumption really on price of fuel. My guess is that you would make that. If the price of gasoline was $2 a gallon, you would probably make it. My guess is the price of gasoline as it is today, you would become well short.

Mrs. **Petrauskas**. Senator Nickles, if I may, and I apologize for interrupting.

I think looking at the European experience is very instructive. While there isn't as much data as all of us would like, if we look at Europe in the mid-1980s and look at what the new car fuel economy, average fuel economy, was in Europe—these are countries that have very large gasoline taxes in some cases. Take the case of Italy. We are talking $3 and change just in terms of a gasoline tax on top of the cost of gasoline.

The fuel economies in those countries are not 34. They are less than 34. So, even with an infrastructure that is very conducive to very small cars—and I'm talking about small, narrow roads—even with other long-standing governmental policies to encourage the purchase of the smaller car, we are still finding that the average levels we believe are less than what has been talked about, whether it's 34 or 40.

And I think when we study this whole issue, we ought to look at that experience and ask ourselves what does that mean in terms of satisfying U.S. transportation needs.

Senator **Nickles**. Concerning the two companies that you represent, if that amendment did pass, would you be importing more automobiles under the present condition? Would you have a reduction in U.S. jobs? Would you have an increase in prices to consumers? Would you answer the questions?

Dr. **Whitman**. Senator, you are quite right, of course, that where petroleum prices are, it would have a tremendous—gasoline prices are, it would have a great impact on the difficulty we would or would not have in meeting the standard.

But let me say that within a few months from now, and by the time any legislation would possibly be passed, we will have released—that is, we will have locked up our 1993 models. That means that anything that we had to do to meet more stringent CAFE standards through the 1993 year could only come in the form of forcing on our consumers a mix of size, of engines, of options, of something that is quite different from what they want.

And there is no question in my mind that that kind of forcing would cost us money, more important, would cost us consumer satisfaction, would tend to make us lose consumers to foreign manufacturers who, as I say, do not face the same constraints. They are now at 32 miles per gallon—the Japanese. So, they wouldn't have to do a thing.

It would probably send some people from American cars to Japanese cars with less fuel efficiency because there are many of those. Good Lord, the Acura Legend, the famous Japanese car, is the same fuel efficiency as our old rear wheel drive Cadillac Brougham. And yet, you would be pushing toward those manufacturers. Inevitably you would see a decline in the competitiveness of American vehicles and therefore more excess capacity, more lost jobs as that result.

Going out beyond 1993, clearly those models are not yet locked up. But as I've said, we don't see technological breakthroughs on the horizon that will enable us to somehow magically and costlessly achieve those increases. Inevitably, again, there would be an element of having to reduce our ability to satisfy the customer which has to mean reduced sales or reduced penetration on the part of the American manufacturers and therefore lost American jobs.

Senator NICKLES. Would you end up being in a situation too as far as the—you keep mentioning the full-size cars that do not or would not meet those standards. If the standards were increased to 34, let's say—and I think what—Mr. Ditlow, you are requesting that the committee would move those to what? Fifty-five by the year 2000? Is that correct?

Mr. DITLOW. We have asked the Department of Transportation to issue a notice of proposed rulemaking to consider 55 by 2001.

Senator NICKLES. So, you want to go to 55 by the year 2001. Senator Metzenbaum wants to go to 34 by the year 2000. Is that correct?

Mr. DITLOW. That is, as I understand, one of Senator Metzenbaum's proposals.

Senator NICKLES. Do you have any concern that if we went to 55, that we would all be driving compacts, and maybe a very significant percentage of those compacts would be foreign?

Mr. DITLOW. To go to the level of 50 to 55 miles per gallon by that time frame would not require a change in mix of vehicles. I am looking at improved technologies to do that.

Senator NICKLES. So, we're going to have all four cycle engines as you mentioned in your one example?

Mr. DITLOW. Certainly improved engine efficiency is one. Direct injection diesels is another. Continuously variable transmissions.

I recall back in 1978 General Motors said that we would be driving all compacts by the year 1985 if we had to meet 27.5. Well, 1985 came and went and the American public was not driving all compact automobiles.

Senator NICKLES. Mr. Ditlow, you mentioned in your statement the 1989 vehicle fleet will consume 2 and a half million barrels per day less gasoline than it would have been if the fleet had the same fuel economy in 1975. Are you giving all credit to CAFE, or don't you think that the marketplace has had something to do with that?

Mr. DITLOW. We believe the marketplace has had something to do with it. Our estimate is that perhaps a million was due to the marketplace, and one a half million was due to the CAFE standards.

Senator NICKLES. Do you have any—I'm almost amused with that. Do you have any valuation where you made that breakdown?

Mr. DITLOW. When one looks at the timing of the introduction of things like the front-wheel drive cars in the 1980 to 1981 time frame, the decisions were made prior to the Iranian shortfall, those decisions were advanced and accelerated by the CAFE standards. And there are numerous studies that have been done, which I'll be glad to provide for the record, that trace the impact of the CAFE standards versus the market forces.

One question one has to ask of the auto companies is if CAFE doesn't make any difference and it's gasoline prices and the market that produced the increases in fuel economy, then why have they fought so hard to get rid of the CAFE standards.

Dr. WHITMAN. I did comment, Senator, that in the last couple of years the CAFE standards have, indeed, become binding on the automobile companies, and it has become increasingly difficult for us to meet those standards. And I commented that the main result seems to be to push consumers around in the marketplace among different manufacturers.

Senator NICKLES. Has CAFE increased the price of automobiles? And if we pass the amendment proposed by the Chairman, would the cost of automobiles, particularly the larger automobiles, go up?

Dr. WHITMAN. Well, one thing it might do—one way that one might force the mix to get consumers to buy a mix different from what they would choose by themselves is to increase drastically the prices of some kinds of automobiles and not of others.

Senator NICKLES. Correct me if I'm wrong, but I feel like that has already happened. I think the cost of your large automobiles is extremely high already. And a lot of that may have—maybe that has something to do with CAFE. Maybe it has something to do with other investments and so on. But the cost of automobiles—we have been talking about CAFE for the last 10 years, but the cost of automobiles has risen, and particularly for the larger, dramatically over the last 15 years.

Let me ask you another question. And I realize there are several inputs to that cost, one of which is emissions. Mrs. Petrauskas, you mentioned in your statement that higher air quality standards work against improvements in CAFE. Is that correct?

Mrs. PETRAUSKAS. Yes, meaning tighter emission standards, other things being equal, deteriorates fuel economy, and then one as to try to recapture that lost fuel economy. And, in fact, that's is what happened in the years since 1975 because we have substantially reduced emissions from automobiles, suffered a fuel economy penalty as a result and then had to make that fuel economy up both to meet the CAFE law and to satisfy our customers' desires for good fuel economy.

Senator NICKLES. So, to meet the emissions standards, it actually means that that has made it more difficult to meet the CAFE standards?

Mrs. PETRAUSKAS. That's correct.

Senator NICKLES. If Congress imposed or EPA imposed greater emission standards, would that make it that much more difficult to meet CAFE?

Mrs. PETRAUSKAS. Yes, that would be true in the case of more stringent exhaust emission standards. And then as we noted in our testimony, as we learn more and more about what it will take to go to substitutes for today's refrigerants with more environmentally benign substitutes, we expect that will have a fairly significant penalty as well.

Senator NICKLES. I'm also concerned about safety. I have a couple of teenagers. I don't know why I make this personal, Mr. Chairman, but I do. And I have one that drives an older Ford which does not meet any CAFE standards. In the 1960s vintage, and it's a gas guzzler by every comparison, any comparison. Maybe we should ban old automobiles. That might have an impact.

But I also have a daughter who has a newer model car, an 1985. But I am concerned about safety. That car happens to be a Dodge, but it also is a Dodge with foreign components, I think a foreign engine or something. But I'm concerned about its safety. It is very lightweight. It will meet your standards, but it also is not near as safe.

Is there a safety factor? In the efforts to meet CAFE, does safety take a back seat in an effort to meet more rigid or increased CAFE standards?

Mr. DITLOW. Safety hasn't certainly——

Senator NICKLES. I'll ask you a question in just a moment, Mr. Ditlow.

Dr. WHITMAN. Well, there is no question that we can't repeal the laws of physics, that when you reduce the mass, that is, the weight of an automobile, all other things being equal, you are going to reduce its ability to absorb energy in a crash and thereby reduce the safety of the occupants.

Now, over time obviously the automobile companies have also instituted a large number of safety improvements, and that has again helped us climb back up from the penalty on safety that you get from weight reduction.

Furthermore, of course, as one adds safety standards, and we are meeting higher and higher safety criteria, very often those things also do require us to add weight when you talk about adding air bags, or adding side beam structure in the doors of automobiles, or when you talk about having safer gasoline canisters. Many of these safety features do add weight, and then in order to meet CAFE, we have to turn around and figure out other ways to get the weight out.

Similarly, in order to compensate for the inherent loss of safety in the sense of the laws of physics by reducing mass, we have to constantly struggle to do other things to get back up. So, as between your old, heavy car and your new, light car, I don't know how it would come out because with the passage of time, as I say, we have made very many safety improvements. And we intend to continue going on to doing that regardless of what happens with CAFE. But there is no question that you do start with an initial disadvantage in crashworthiness, which there is no way to abolish when you reduce the mass of vehicles.

Senator NICKLES. Mr. Ditlow, did you want to add something?

Senator METZENBAUM. Could I just interject a point? One of the staff just pointed out to me that the National Highway Traffic Safety Administration just put out a report four months ago saying that the National Highway Traffic Safety Administration said today that 1988 was a year of significant gains in highway safety and that highway travel in the country now is safer than at any time in modern history. Now, I suppose the CAFE standards did that, but there were probably a few other things as well.

Senator NICKLES. It's because we increased the speed limit. [Laughter.]

Mr. Ditlow, did you want to add something?

Mr. DITLOW. Yes, I did.

In 1975 when the CAFE act was passed, the fatality rate was 3.6 deaths per 100 million vehicle miles traveled. By 1988 it was down to 2.3. And that is due to improvements in safety at the same time that we were doubling fuel economy and reducing the weight of vehicles by 1,000 pounds.

One just very good example is the Volkswagen Rabbit with the automatic seat belts. That is about a 2,000 pound car, and the injury rate on that Volkswagen Rabbit with the automatic seat belts in the time frame of about 1977 to 1980 was actually less than the Ford Crown Victoria, which was about close to twice the weight of that vehicle.

Senator NICKLES. Well, I am sure that you can point out a lot of examples. You have highlighted the success the Volkswagen has had. You have highlighted the success that Toyota has had in comparison to domestic manufacturers, but this Senator is not particularly interested in seeing us import more automobiles.

Mrs. PETRAUSKAS. I must respond to two observations. Mr. Ditlow make comparisons, but he makes incomplete comparisons. His chart on the comparison of the Toyota vehicle and the Ford Tempo was not quite complete because he didn't list the price difference in the two vehicles and he didn't point out that the Tempo, which is available with air bags I might add, is available for sale at $2,500 less than that Toyota.

And the comparison between the VW vehicle and the Crown Victoria vehicle—I don't know what the basis of his comparison is, but in every single publication I have seen for the last 10 years that is put out by the Insurance Institute for Highway Safety in terms of those vehicles that have the best safety records, the Crown Victoria or its companion car, the Grand Marquis, has been in the top 10. That is not a knock against Volkswagen, understand, but those are the facts.

The facts are all cars are required to meet the same safety standards. The facts are that all of us, I think it is fair to say, are working hard to improve the safety of our vehicles every year. But it is also true that when a small car hits a larger object, whether it is a car or a telephone pole or a tree, if you're in a light car, other things being equal, you will be worse off.

Senator NICKLES. To our panelists, thank you very much.

Mr. Chairman, thank you.

Senator METZENBAUM. I want to say to my colleague, who I am pleased spent the time with us this morning, that the reason you're paying so much for that bigger car is that General Motors made $8,200 a year on their cars in—on the luxury cars in 1984 and Ford made $8,200 on their luxury cars in 1984, whereas on all the other cars, they made anywhere from about $1,000 to the top of $4,500. So, I think the reason is that they think you rich people who drive those luxury cars—they're entitled to make more profit on you.

Senator NICKLES. Be careful.

Senator METZENBAUM. Okay. [Laughter.]

Senator NICKLES. Mr. Chairman, I would be interested in having a comment or response from Ford and GM. I don't know. I mentioned a car. I was talking about a 1986 or 1985 station wagon that I have, and I think it cost about $18,500. And I thought that was too expensive. I don't know what the are today, but I would be surprised that they made $8,000 on that automobile. That sounds a little——

Senator METZENBAUM. That was a 1984 you said?

Senator NICKLES. That was a 1985 or 1986.

Dr. WHITMAN. I would be surprised too. I'm never quite sure where these profit numbers come from.

But let me say the cars which we have the toughest time on, where we take the biggest losses, are those cars where there is a discrepancy between the capacity we have, the number we expect to sell and the number we ultimately sell.

And one of the biggest disaster areas that we have had in recent years in that respect have been our so-called EK cars, the Seville, the Toronado, the Cadillac DeVille and so forth, which we downsized, which we put tremendous effort into down-sizing and making smaller in response to an effort to increase our fuel economy. And frankly, those cars turned out to be not what the customer wanted. They said what happened to the old ones. Those are too small. They don't look right. And we lost a bundle on those.

Later, we have gone back and we have restyled them, and they are coming back up again because they come much closer now to what the customer wants in that kind of an automobile.

But where we really take a beating is where, for one reason or another, we are unable or we don't meet the customers' desires and the customers' expectations for a particular kind of vehicle. And the vehicles I have listed, by the way, where we took such a beating were large cars, luxury cars. And let me tell you those proved to be a very, very difficult situation for us. We have now got them turned around, and they're coming back and coming back rapidly, but it will take some time before we can overcome that situation.

Senator METZENBAUM. I don't want to get into a debate with you, but the fact is that some of the luxury cars that are coming in that are getting the biggest dollar are foreign cars, and aren't big. They are very small, as a matter of fact. And they have a certain style about them that has attracted the American customer. And I think Lincoln—I just saw one of their new luxury cars that seems to be a pretty hot number at the present time. I think that you can't say it's because it's big or it's small. I think it depends upon the style. I think it depends upon—I remember when friends of mine bought the Cadillac diesel, and they were embarrassed it made so damned much noise. And I didn't enjoy the noise either riding with them. But there are different factors that go into why people buy automobiles.

Dr. WHITMAN. Absolutely.

Senator METZENBAUM. So, anyhow, let me just wind up this hearing by asking Dr. Ebinger if he believes that Dr. Whitman is correct that energy conservation truly has nothing to do with energy security.

Mr. EBINGER. I do not believe that, Mr. Chairman. I believe the record and many studies that I would be glad to obtain and give to the committee for the record suggest that energy conservation has made a major contribution in a number of areas as have energy production options.

If I may just add, to add one element to this debate, and with all due respect to the automotive manufacturers represented here today, that I think when we talk about consumer satisfaction, that is certainly something we would all like to see, but we have other concerns in this country. We have concerns about national security. And if we import more oil because we are not building the most fuel efficient cars, this has a deleterious impact on the Nation's trade balance which, in turn, affects American jobs. It affects American interests rates. It affects Americans' ability to buy homes and cars.

And I think when we talk about consumer satisfaction, we should also not lose sight of the fact that if we burn more gasoline than we need to, we are contributing, albeit perhaps a small amount, but we are contributing global warming. We are contributing to the ozone depletion, and these are all public policy concerns of equal weight in my view with the narrow view of what an individual consumer wants. There has to be a national interest above an individual interest, Mr. Chairman.

Senator **Metzenbaum**. Thank you, Dr. Ebinger.

And, Mr. Ditlow, Dr. Whitman's statement raised the issue of safety in fuel efficient cars. Can you briefly address that because I'd like to adjourn this hearing in about three minutes.

Mr. **Ditlow**. Fuel efficiency and safety are two complementary goals. You can design safety into more fuel efficient vehicles, and we have a range of options from air bags to improved side restraints, to better interior compartments of cars. And we can continue the decrease in traffic fatalities at the same time we continue the increase in motor vehicle fuel economy.

And I would like to be able to submit a short memo to the record including a response to Mrs. Petrauskas showing the Insurance Institute's information on how the Rabbit does, in fact, do better than the Crown Victoria.

Senator **Metzenbaum**. We'll be happy to receive it.*

I want to thank all of the panelists for their participation. Again, I want to say that our door is open to you if you want to have any input with respect to our legislative proposals. We certainly would welcome your participation.

[An additional statement for the record from the National Automobile Dealers Association follows:]

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*Not received.

# Statement of

# National Automobile Dealers Association

on Corporate Average Fuel Economy Standards

before the

United States Senate

Committee on Energy and Natural Resources
Subcommittee on Energy Regulation and Conservation

April 4, 1989

Mr. Chairman and Members of the Committee:

The National Automobile Dealers Association (NADA) appreciates the opportunity to comment on the impact at the retail level of changing current Corporate Average Fuel Economy Standards (CAFE). The NADA is a national trade association representing over 20,000 franchised new car and truck dealers across the country. NADA members are primarily engaged in the retail sale of new and used motor vehicles, both foreign and domestically produced. NADA members are also engaged in automobile service, repair, and parts sales.

In 1975, during the aftermath of the energy crisis created by the 1973-1974 oil embargo, Congress adopted the Energy Policy Conservation Act (EPCA). As a part of the Act, Congress established an automotive fuel economy regulatory program to compel vehicle manufacturers to produce more fuel-efficient passenger cars and light-duty trucks. Congress specified Corporate Average Fuel Economy (CAFE) standards for certain model year passenger cars, including a 27.5 mpg standard for 1985 and subsequent model years. Compliance with the CAFE standard is determined by formulating a weighted average of a manufacturer's total car production each year, including small, medium, and full-sized vehicles. Therefore, manufacturers which produce full-sized vehicles as a part of their total production have the most difficulty in complying with the standard.

NADA does not have access to information on manufacturer product plans and CAFE projections, but our members have first-hand knowledge of consumer demand in the marketplace. We have observed over the years that a major determinant of consumer demand is the price of gasoline. Unleaded gasoline today is selling for approximately $1.00 a gallon. This price is only about one-third of what was predicted in 1975 and is not expected to increase much over inflation in the next few years. As a result of these relatively low gasoline prices, recent trends in the marketplace have shown a pronounced shift in demand from smaller, more fuel efficient vehicles to larger, family-sized cars. This is causing some difficulty for manufacturers of full size cars to meet the CAFE standard. Manufacturers have structured a number of incentive programs in an effort to stimulate demand for fuel efficient vehicles and thus, assist in offsetting the CAFE shortfall. While these incentive programs have had some effect on consumer demand in the short term, it is clear that these programs cannot control consumer preference. Many families seem to feel that their transportation needs are best served by larger, family-sized vehicles.

Automobile dealers do not have the technical expertise to determine how manufacturers might attempt to comply with an increase in the CAFE standard. However, it is clear to us that a significant increase in the standard will result in reduced model availability. Those models for which production is most likely to be limited or discontinued will be the station wagons and full-sized sedans. Under current market conditions, these models are among the most popular family vehicles. Not only do these cars more adequately meet the family transportation needs, they also have been shown to provide more crash protection for the occupants.

In addition to the question of model availability, we are very concerned that a significant increase in the CAFE standard will result in poor vehicle performance. In today's market, there are also a number of mid-sized vehicles that do not meet the 27.5 mpg standard. In order to achieve an even higher level of compliance, we feel the manufacturers will be forced to downsize the engine in these vehicles to a level that will result in sluggish performance and customer dissatisfaction. Over the years, experience has shown that when the manufacturers attempt to produce extremely fuel efficient vehicles, performance and driveability often suffer.

These matters are of great concern to the new car dealers of the nation. We believe that Congress also recognized these matters as potential problems when it enacted the original Energy Policy Conservation Act of 1975. The Committee report to the House-passed version of the EPCA specifically addressed these concerns:

> "...the automotive industry has a central role in our national economy and that any regulatory program must be carefully drafted so as to require of the industry what is attainable without either imposing impossible burdens on it or unduly limiting consumer choice as to capacity and performance of motor vehicles." (H.R., Rep. No. 94-340, 94th Congress, 1st Session 87, 1975) (Emphasis added.)

We sincerely believe that a mandate which significantly increases the CAFE standards could result in widespread consumer dissatisfaction, disruption in both automobile manufacturing and small business retailing, and dislocation in the workforce of manufacturers and dealers alike. We appeal to the supporters of a higher CAFE standard not to be too blasé about these concerns. We think that they are real and not imagined.

Mr. Chairman and members of the Committee, once again we appreciate the opportunity to comment on this issue, and we will be happy to provide any assistance that the Committee might need in its deliberations on this matter.

Senator **Metzenbaum**. The hearing stands adjourned.

[Whereupon, at 11:58 a.m., the hearing was adjourned.]

[The appendix follows:]

# APPENDIX

## RESPONSES TO ADDITIONAL QUESTIONS

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U.S. Department
of Transportation
**National Highway
Traffic Safety
Administration**

400 Seventh Street, S.W.
Washington, D.C. 20590

APR 28 1989

The Honorable Howard M. Metzenbaum
Chairman, Subcommittee on
Energy Regulation and Conservation
Committee on Energy and Natural Resources
United States Senate
Washington, DC 20510-6150

Dear Senator Metzenbaum:

As requested in your letter of April 11, 1989, I have enclosed the responses of the National Highway Traffic Safety Administration to the minority questions raised as a result of my testimony before the Subcommittee on Energy Regulation and Conservation on April 4, 1989.

Please let me know if I can be of any further assistance to the subcommittee.

Sincerely,

Howard M. Smolkin

Howard Smolkin
Managing Director

Enclosure

Get it together!
SAFETY BELTS SAVE LIVES

ENCLOSURE

## MINORITY QUESTIONS FOR ADMINISTRATION WITNESSES

Question 1: Would you agree that our growing foreign oil dependence poses a threat to our economic security as well as energy security?

Answer: Yes. As our dependence on imported oil grows, the economic as well as energy security of the country is affected. However, the amount of risk, or threat, depends on the price of petroleum and the source country of the imports, in addition to the import share of national consumption. For example, we believe that importing oil from Great Britain does not pose the same risk to our security as does importing oil from the Middle East.

Question 2: What is the current national average fuel economy of automobiles in use in the United States? How does this compare to Europe or Japan?

Answer: Values for the average fuel economy of the entire passenger car fleets of various countries is tabulated below. These preliminary data, which apply to all passenger cars in use — not just new vehicles — are based on individual government submissions to the International Energy Agency. The values are for 1987 except those noted by an asterisk (*), which are for 1986, the latest year for which data were available. For reference, the average prices of gasoline in these countries is also shown. The prices are as of January 1987 and are from the International Energy Review.

| Country | Fleet Average Fuel Economy, mpg | Fuel Cost, U.S. Dollars/Gal. |
|---|---|---|
| Portugal | 23.3 | 2.98 |
| Denmark | 28.7* | 3.58 |
| Spain | 28.3 | 2.28 |
| Greece | 26.6 | 2.16 |
| Germany | 22.4* | 2.09 |
| Switzerland | 25.4* | 2.38 |
| Japan | 22.0* | 2.89 |
| Canada | 19.9 | 1.30 |
| United States | 19.4 | 0.87 |

Question 3: What is the average fuel economy of Model Year 1988 and 1989 automobiles sold in the United States?

Answer: The average fuel economy of the U.S. new passenger car fleet for model years 1978 through 1989 is tabulated below. The values for model years 1987 and 1988 are preliminary, as final values are not yet available for every manufacturer. The model year 1989 value is derived from manufacturers' projections from early in the model year and is likely to change somewhat.

| Model Year | Fleet Average Fuel Economy, mpg | CAFE Standard, mpg |
|---|---|---|
| 1978 | 19.9 | 18.0 |
| 1979 | 20.3 | 19.0 |
| 1980 | 24.3 | 20.0 |
| 1981 | 25.9 | 22.0 |
| 1982 | 26.6 | 24.0 |
| 1983 | 26.4 | 26.0 |
| 1984 | 26.9 | 27.0 |
| 1985 | 27.6 | 27.5 |
| 1986 | 28.0 | 26.0 |
| 1987 | 28.2 | 26.0 |
| 1988 | 28.7 | 26.0 |
| 1989 | 28.3 | 26.5 |

Note that the fleet average exceeds the standard in every model year except 1984 where it fell 0.1 mpg below the standard. Also, in model years 1986 through 1989, the fleet average is projected to exceed the original statutory standard of 27.5 mpg. Finally, note that, except for a small decline in model year 1984 and a possible small decline for 1989, the fleet average has increased every year since the CAFE standards were established.

**Question 4**: At this time, does the Administration support any change in either CAFE Standards or current law?

Answer: The future role of CAFE standards in the nation's effort to conserve energy is undergoing review as the Administration examines the effects of energy choices on the national economy and the world environment. The question of how to make further gains in fuel efficiency will require a consideration of a multitude of factors -- economic practicability; technological feasibility; possible tradeoffs regarding safety, comfort, passenger-carrying capacity and performance; environmental effects; impacts on domestic employment; and effects on the U.S. economy -- as well as energy conservation. As we conclude this review we will be better prepared to discuss the applicability of the current requirements of the CAFE standard and the law to future model years.

**Question 5a: If our national energy strategy is to foster improvements in energy efficiency, how would you propose to take these indirect costs [the cost of our dependence on oil imports] into consideration in the market place, or is the only alternative more stringent CAFE standards?**

Answer: We have been concerned that the CAFE law acts primarily on the supply of fuel efficient vehicles, but does little to affect the demand for fuel efficiency or the demand for petroleum for travel needs by consumers. The nation has accomplished much toward improving energy security since the first oil crisis with such programs as the Strategic Petroleum Reserve and the decontrol of oil prices. But CAFE standards are only one of many ways to encourage oil conservation. Other considerations in a balanced energy policy might include such factors as the further encouragement of public transportation and making our roadways more efficient, effecting a decline in consumer demand for oil for transportation, and additional means of conservation of non-transportation oil uses.

Questions 5b and 5c: Would you support a gasoline tax in preference to CAFE standards as a means for internalizing these societal costs? Would a gasoline tax provide sufficient incentive for automobile manufacturers to market and consumers buy more efficient cars?

Answer: The administration's policy is not to seek increased taxes.

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United States
Environmental Protection
Agency

External Affairs (A-102)
Washington DC 20460

EPA

Legislative Analysis

MAY 15 1989

Honorable Howard M. Metzenbaum
Chairman, Subcommittee on Energy Regulation
and Conservation
Committee on Energy and Natural Resources
United States Senate
Washington, D.C. 20510

Dear Mr. Chairman:

Enclosed, for insertion in the hearing record, are EPA's responses to questions which you forwarded on behalf of the Subcommittee following the April 4 hearing on automobile fuel efficiency standards.

Please feel free to contact us if we can be of any further assistance.

Sincerely yours,

A. Henry Schilling
Director, Office of
Legislative Analysis

Enclosure

1. There is a general agreement that higher transportation fuel efficiency must be part of any national energy strategy. The testimony of DOE and others indicates that there has been a leveling in fuel economy progress in recent years due to low gasoline prices.

Yet, today the U.S. is more dependent on foreign oil than it was just prior to the 1973 Arab oil embargo -- and that dependence continues to grow. This dependence is so great that, earlier this year, when the Department of Commerce released the results of its Trade Expansion Act investigation on oil imports, the Department concluded that:

> "There have been substantial improvements in U.S. energy security since the last section 232 petroleum finding in 1979. However, declining domestic oil production, rising oil imports, and growing Free World dependence on potentially insecure sources of supply raises a number of concerns, including vulnerability to a major supply disruption. The investigation found that the maintenance of U.S. access to sufficient supplies of petroleum is essential to our economic security, foreign policy flexibility, and defense preparedness. Given the above factors, it was found that petroleum imports threaten to impair the national security."

Would you agree that our growing oil dependence poses a threat to our economic security as well as energy security?

A. Anyone familiar with the experiences of the 1970's would have to agree that increasing dependence on imported oil creates significant economic and energy security risks. EPA's analyses of future energy use have focused primarily on the local, regional and global environmental benefits of efficiency improvements and alternative energy sources which can reduce fossil fuel, including oil, consumption. However, we also agree with published conclusions by the DOE and others that important economic and energy security benefits would result as well.

While we have not yet analyzed comprehensively the total benefits of reductions in fossil fuel use, we believe that when such analysis is done, it will show that the potential long term environmental, economic and national security benefits would justify far greater investments in energy efficiency and alternative fuels than are currently being made in our economy.

2. What is the current national average fuel economy of automobiles in use in the United States? How does this compare to Europe or Japan?

A. Department of Energy published data indicates that in 1986, the average fuel efficiency of all passenger cars in use in the U.S. was 18.3 miles per gallon. (U.S. Department of Energy, Annual Energy Review 1987, Energy Information Administration, Washington,D.C. 1988)

The attached figure compares U.S. fleet fuel economy data with several other countries. Note that the units are liters per 100 kilometers rather than miles per gallon. Passenger car fuel economy is somewhat higher in most other industrialized countries. The attached table from a 1987 report by the International Energy Agency (IEA, Energy Conservation in IEA Countries, OECD, Paris, 1987) compares new car fuel economy in several industrialized countries expressed in metric units of liters per 100 kilometers. As shown in the table, U.S. automobile fuel economy is still somewhat higher than most of the other countries listed, although the difference has narrowod significantly since the mid 1970s. It should also be noted that this comparison excludes light trucks which make up a larger fraction of new passenger vehicles than in most other countries.

3. What is the average fuel economy of Model Year 1988 and 1989 automobiles sold in the United States?

A. Published EPA test data show that the rated combined city/highway fuel economy for new automobiles sold in the U.S. in 1988 averaged 28.4 miles per gallon. For light duty trucks, also increasingly used as passenger vehicles in this country, the average was 21.2. The overall average for light vehicles was 25.8. These, of course, are rated test values. It is believed that the actual on road mileage would be somewhat less. (Source: R.M. Heavenrich and J.D. Murrell, Light Duty Automotive Technology and Fuel Economy Trends through 1988, EPA/AA/CTAB-88-07, U.S. Environmental Protection Agency, Ann Arbor, MI, June 1988.) We do not yet have complete data for model year 1989, but anticipate that average fuel economy for 1989 may be slightly lower than the 1988 figure.

4. At this time, does the Administration support any change in either CAFE standards or current law?

A. The Administration does recognize the importance of improving fuel economy in highway vehicles for environmental, economic and energy security reasons. Alternative policy approaches to achieving fuel economy improvements are being evaluated currently by several Agencies within the Federal Government. As yet, there is no Administration position on whether existing CAFE standards should be retained or modified or whether other methods of promoting increase fuel economy should be adopted.

5. Several witnesses have suggested that present gasoline prices may serve as a disincentive when it comes to automobile fuel economy. Concern has been voiced about how long it would take for an American consumer to recover additional costs of further fuel economy improvements, whether introduced voluntarily by auto manufacturers or required by CAFE standards. The implication is that CAFE standards are simply a matter of "cost-benefit" analysis.

a. But there is a national cost to our dependence on oil imports. While only partially reflected in the price of cars, that cost is reflected throughout our economy and ultimately the American consumers must pay that cost.

If our national energy strategy is to foster improvements in energy efficiency, how would you propose to take these indirect costs into consideration in the market place, or is the only alternative more stringent CAFE standards?

A. In carrying out cost-benefit analysis of CAFE standards or any other energy efficiency policy measure, it is important to include the environmental benefits and other economic and security benefits which would accrue to society at large but would not normally be fully reflected in consumer economic choices. If we are convinced that these benefits justify policy intervention to bring about more energy efficient choices than would otherwise occur in the market place, a range of potential policy measures is available and should be evaluated. These include direct regulation of efficiency as in CAFE as well as fuel taxes, automobile excise taxes and incentives, information programs, research and development, etc.

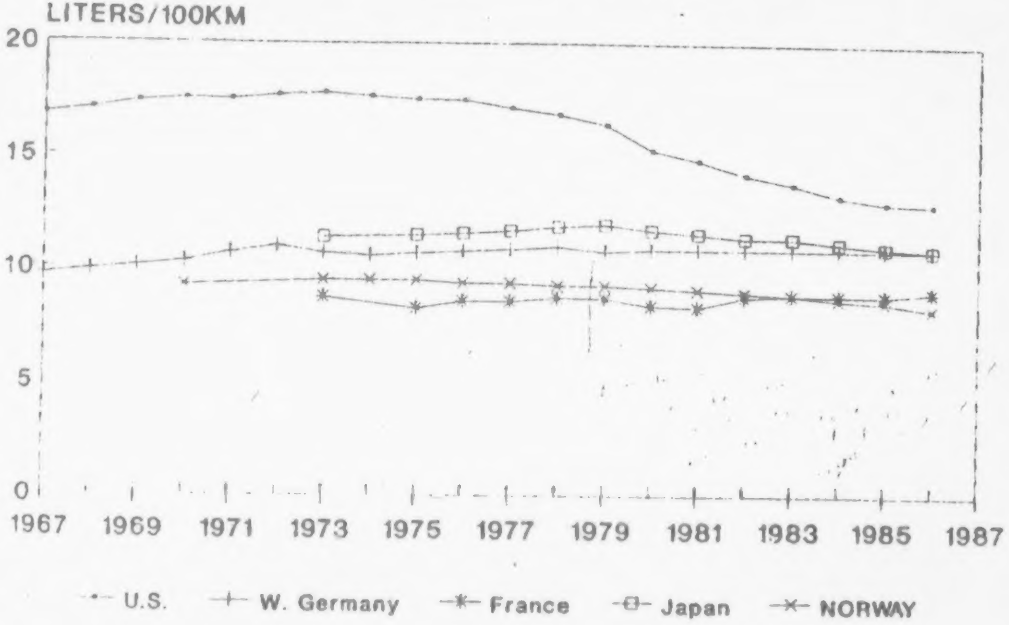
b. Would you support a gasoline tax in preference to CAFE standards as a means of internalizing these societal costs?

A. A range of policy actions is available for encouraging or mandating auto efficiency improvements. A gasoline tax is one such option. No Administration position has been developed either for or against gasoline taxes or other policy actions as yet.

c. Would a gasoline tax provide sufficient incentive for automobile manufacturers to market and consumer's to buy more efficient cars?

A. Any gasoline tax, by raising the price of gasoline, would provide some incentive to consumers to buy more efficient cars, and therefore to manufacturers to produce them. It may be that a very large tax would be required to cause this to occur rapidly. A large gasoline tax increase could be politically difficult, and could have a number of regional and macroeconomic impacts which have not been fully evaluated. It is necessary to compare the costs, benefits and risks of this approach with a range of other policy options and combinations of options to determine the most desirable approach. To my knowledge, such a comparison has not been completed as yet.

## AUTOMOBILES FUEL ECONOMY ON THE ROAD FLEET AVERAGES



SOURCE: Lawrence Berkeley Laboratory, Feb. 1989

Figure 18

*Table 4*

**Actual New Passenger Car Fuel Efficiency**

(Gasoline consumption in litres per 100 kilometres)

| | 1973 | 1978 | 1979 | 1980 | 1982 | 1983 | 1984 | 1985 | Projections/Targets 1990 | Projections/Targets 2000 |
|---|---|---|---|---|---|---|---|---|---|---|
| Australia | n.a. | 11.8 | 11.2 | 10.1 | 9.8 | 9.5 | 9.5 | | 8.5[1] | |
| Canada | n.a. | 11.5 | 11.5 | 10.3 | 8.5 | 8.5 | 8.4 | 8.2 | 7.4 | 6.8[2] |
| Denmark | 9.0[3] | n.a. | n.a. | 8.6 | n.a. | 7.3 | 7.0 | 7.1 | | |
| Germany | 10.3 | 9.6 | 9.4 | 9.0 | 8.3 | 8.0 | 7.7 | 7.5 | | |
| Italy[4] | 8.4 | 8.3 | 8.3 | 8.1 | 8.3 | 8.0 | n.a. | 7.8 | 7.4 | |
| Japan | 10.4 | 8.8 | 8.6 | 8.3 | 7.7 | 7.8 | 7.8 | 7.8 | | |
| Netherlands | n.a. | 9.2 | 8.9 | 8.8 | 8.5 | n.a. | | 9.1 | 8.6 | 7.8 |
| Sweden | n.a. | 9.3 | 9.2 | 9.0 | 8.6 | 8.6 | 8.5 | 8.5 | | |
| United Kingdom | 11.0 | 9.1 | 9.0 | 8.7 | 8.1 | 7.9 | 8.8 | 7.6 | | |
| United States | 16.6 | 11.8 | 11.6 | 10.0 | 8.9 | 9.0 | 8.9 | 8.7 | 8.8 | 8.2 |

1. 1987 target.
2. 1995.
3. 1975.
4. The figures for Italy represent average efficiency of the total car fleet.

**Source:** IEA Country Submissions.

Responses of General Motors Corporation to Questions from the Senate Subcommittee on Energy Regulation and Conservation.

Submitted — May 8, 1989

Question 1: Would you agree that our growing foreign oil dependence poses a threat to our economic security as well as energy security?

Response: No. Energy security is the flexibility to quickly change the level of use and/or quickly switch to alternative sources in the event of a supply disruption. On that basis, our nation and the world has made substantial progress since the first OPEC pricing actions. On the demand side, the use of petroleum has proven far more responsive to price increases than anyone ever thought was possible. Likewise, the response on the supply side has proven much greater than anyone had thought. Whereas it was once thought that $100 and more per barrel petroleum was just around the corner, we now know that even $40 is probably not sustainable. At presently foreseeable levels of demand, the existence of substantial excess capacity in crude oil production makes it highly unlikely that a supply disruption could result in a large and sustainable increase in the price of petroleum.

In addition to this excess capacity, many options now exist that were not available in 1975, including the Strategic Petroleum Reserve and similar reserves in Europe and elsewhere and a significantly increased ability to quickly switch to petroleum substitutes within the industrial sector. In addition, the elimination of price controls on gasoline insures that the 180 million or so cars and trucks on the road in this nation would face the right signals if and when such a disruption occurs — signals to both adjust their driving and purchasing habits.

Regarding the impact of rising petroleum imports on the domestic economy, it should be noted that the 1988 import share of 37 percent, while up from 27 percent in 1985, is still substantially below its peak of 47 percent in 1977. In addition, lower energy prices have been a very positive factor in contributing to the nation's economic growth since that time. Given the substantial increase in the ability to deal with OPEC disruptions, we should be very careful about pursuing policies which decrease our reliance on foreign oil at the expense of the competitiveness of American industry.

Question 2: What is the current national average fuel economy of automobiles in use in the United States? How does this compare to Europe or Japan?

Response: The current U.S. in-use passenger car total national average fuel economy for calendar year 1987 was 19.2 mpg (Reference: 1986 - 18.3 mpg; 1985 - 18.2 mpg; 1984 - 17.8 mpg; and 1983 - 17.1 mpg). As older, less-fuel efficient vehicles are replaced with newer, increasingly efficient ones, the average fuel economy of the passenger cars will continue to increase throughout the 1990s and beyond.

The 1987 in-use passenger car average for Japan and Europe is not known; however, because of predominate use of smaller cars historically due to taxes, based on such criteria as horsepower, cubic inch engine displacement, number of cylinders, etc., their average would be expected to be higher. In the future, particularly, in Japan, fleet average fuel economy is likely to decline because Japan has significantly reduced taxes assessed against their large cars. Consequently, many Japanese manufacturers are or will be producing larger cars with higher performance engines (V-6 and V-8) resulting in lower fuel economy.

We believe that it is inappropriate to make these broad comparisons among countries for a number of reasons, namely different: economies, tax systems, road systems, demographics, and emission, safety, and crashworthiness regulatory standards. The European Community made the decision to live with high motor fuel taxes long ago. Most Americans do not believe that this European experience is at all applicable to the U.S. With respect to transportation, the Europeans operate under vastly different circumstances and conditions for example, more congestion and more mass transit systems. This difference explains most of the divergence between America's use of fuel in surface transportation and that of European countries with which it is frequently compared. What the Europeans have determined as the appropriate price of motor fuel for them would be totally unacceptable to American consumers.

| | |
|---|---|
| Question 3: | What is the average fuel economy of Model Years 1988 and 1989 automobiles sold in the United States? |
| Response: | The latest data from the National Highway Traffic Safety Administration, based on manufacturers' required reports, indicate that the projected average fuel economy of imported and domestic passenger cars sold in the United States in MY 1988 and 1989 is as follows: |

| Model Year | Passenger Cars Fuel Economy |
|---|---|
| 1988 | 28.7 |
| 1989 | Indeterminate * |

* 1989 Model Year is still underway.

Question 4a: If our national energy strategy is to foster improvements in energy efficiency, how would you propose to take these indirect costs into consideration in the market place, or is the only alternative more stringent CAFE standards?

Response: As indicated our response to Question 1, we believe that a narrow focus on the level of oil imports can say very little about the nation's energy security. We therefore disagree with the premise that there are significant "indirect costs" arising from energy security concerns that justify government intervention into the marketplace. Measures which increase the nation's flexibility in dealing with energy supply disruptions (for example, enhancing the Strategic Petroleum Reserve and encouraging development of a wide variety of energy sources and the flexibility to choose among them) are more likely to pay far higher dividends in promoting the nation's energy security than are measures narrowly targeted at producing energy efficiency gains in particular sectors of the economy. In addition, they are less likely to adversely affect the competitiveness of U.S. industry.

As discussed in the testimony, if we are to pursue any proposed regulatory program it must meet the tests of effectiveness, efficiency, and fairness. As further discussed in the testimony, CAFE fails all three of these tests. It is ineffective — the current program may well increase energy consumption by shifting consumers away from purchasing relatively fuel efficient new vehicles produced by full-line manufacturers and towards purchasing less fuel efficient vehicles produced by unconstrained manufacturers or retaining their old less fuel-efficient vehicles. It is inefficient, since studies show that at levels where CAFE may actually result in net energy savings it does so at extraordinary cost to the consumer. Finally, it is unfair. It imposes all of the costs of seeking energy efficiency on a very limited base — purchasers of new cars and full-line manufacturers and their employees.

| | |
|---|---|
| Question 4b: | **Would you support a gasoline tax in preference to CAFE standards as a means for internalizing these societal costs?** |

Response: GM would endorse neither program. Programs which work with market forces and not against them stand a much greater chance of passing the tests of effectiveness, efficiency, and fairness. A gasoline tax, however, is far too narrowly based to pass these tests.

Our Economics Staff estimates that a 15 cent per gallon increase in the Federal tax -- much lower than is required to dramatically alter energy-related behavior -- would reduce sales of domestically-produced vehicles by up to 500,000 units per year and result in elimination of 120,000 jobs in the auto and associated industries. The principal reasons for this result are that the tax would reduce disposable income and that the increased vehicle operating costs resulting from the higher tax would slightly extend the average holding period for vehicles being replaced. This increase in the holding period translates into a significant impact on sales. Our findings are consistent with other studies both inside and outside the auto industry.

An increase in the gasoline tax would not only affect the American auto industry and its employees. It also would adversely affect the American public in especially unfair ways. For example, such a tax is highly regressive, disproportionately impacting the lower income groups. A Congressional Budget Office study shows that the lowest group (under $5,000) spends, as a share of income, more than six times as much on gasoline taxes as does the highest income group (above $5,000).

A gasoline tax increase also imposes an unequal burden on households located in less-densely populated areas of the nation where people generally depend more on personal vehicles and must drive longer distances to work or to obtain access to services. It would also dampen economic growth and be inflationary.

Question 4c: Would a gasoline tax provide sufficient incentive for automobile manufacturers to market and consumers buy more efficient cars?

Response: In a very limited sense, such a program would be effective. Such a tax would provide consumers with incentives to purchase more fuel efficient cars and therefore for manufacturers to market them. But such a program's narrow focus on achieving energy efficiency only in the transportation sector ignores the possibilities for achieving potentially greater or less costly energy improvements in other sectors. Narrowly-based incentive schemes, like increasing the gasoline tax, are therefore inherently inefficient. Furthermore, like any regulatory program that singles out a sole activity to bear the entire burden of achieving a social goal, placing the entire burden of improving energy efficiency on users of gasoline is unfair. If encouraging energy conservation is a legitimate goal, should not the costs of achieving that goal be faced by all producers and consumers, not merely those of transportation services?

Question 5: Would you care to comment on the testimony of any of the other witnesses?

Response: Many references were made to the recent study conducted by the Office of Technology Assessment (OTA). As a result of that study, OTA found that overall fleet fuel economy potential is a function of consumer acceptance. Moreover, it is for this reason, among others that OTA has carefully distinguished its preliminary recommendation that there is a potential for the entire domestic fleet to reach 33 mpg by 1995 from a conclusion that individual manufacturers should be expected to meet a CAFE standard at that level. GM believes that even the "potential" cited by OTA for the entire domestic fleet to reach 33 mpg may be overly optimistic, because of the uncertainties regarding technology and gasoline prices and availability (the principal determinants of consumer demand) in the future.

The recent OTA testimony on its study and GM's comments to OTA during the last year are attached for the subcommittee's further review and consideration.

We believe the testimony of the other witnesses at the 4/4 hearing must be evaluated in light of the following recent research work, done on the impact of the CAFE regulatory program:

| TAB | STUDY |
|---|---|
| I | Office of Technology Assessment testimony on its study entitled "Developments in the Fuel Economy of Light-Duty Highway Vehicles." |
| II | Federal Trade Commission, "The Impact of Automobile Fuel Economy Standards," by A. Kleit, Working Paper No. 160. |
| III | Robert W. Crandall and John D. Graham, "The Effect of Fuel Economy Standards on Automobile Safety." |
| IV | Robert W. Crandall et all, "Regulating the Automobile," Regulation of Fuel Economy, chapter 6. |

## INCREASED EFFICIENCY POTENTIAL FOR THE U.S. FLEET OF HIGHWAY PASSENGER VEHICLES

Statement of

Steven E. Plotkin
Senior Associate
Office of Technology Assessment

Before the

Subcommittee on Oversight and Investigations
Committee on Energy and Commerce
U.S. House of Representatives

April 10, 1989

Mr. Chairman and members of the Subcommittee, thank you for this opportunity to share with you some interesting findings of our ongoing assessment of Technological Risks and Opportunities in U.S. Energy Supply and Demand. This study was originally requested by the Energy and Commerce Committee including the Subcommittee on Energy and Power. Other Committees now endorsing the study include the Committee on Government Operations in the House, and the Committee on Energy and Natural Resources in the Senate.

I will discuss today our findings on the efficiency likely to be achieved by the fleet of light duty vehicles if current government policies do not change, and the potential for additional increases in new vehicle energy efficiency that could be obtained by added incentives for fuel savings. The testimony will not discuss potential fuel savings that could be achieved by reductions in travel demand, shifts to other modes (mass transit, bicycles), improvements in traffic flow, improved maintenance of older vehicles, or more rapid replacement of the fleet, but these could also play an important role in reducing oil use.

The findings I will present are based on in-house OTA analysis and literature review, a workshop on light duty fuel efficiency held last September at OTA, work by our contractor, Energy and Environmental Analysis, Inc. (EEA), and extensive comments obtained during peer reviews of both our own writing and that of our contractor.[1] The findings discussed here have been thoroughly reviewed according to standard OTA procedures. Some data appears, however, that was added subsequent to the review, and sources are appropriately cited.

*SUMMARY POINTS*

- The U.S. automobile fleet accounts for about 30 percent of all U.S. oil consumption; the total "light duty fleet," which also includes vans and light trucks, accounts for 39 percent of oil consumption. These fleets represent the largest available targets for reducing U.S. petroleum use.
- The fuel efficiency of both fleets will continue to improve over the next decade as newer, more efficient vehicles replace older ones.
- The continued improvement in fleet efficiency will be slowed, however, by a slowdown in improvement in new vehicles. Although the fuel efficiency of the new car fleet essentially doubled between 1974 and today, a continued rapid rate of improvement is extremely unlikely during the remainder of this century if current conditions continue. A combination of factors -- low fuel prices, increasing sales of luxury and performance features, continued demand for certain older car models, and so forth -- is expected to drastically slow the rate of future efficiency improvement, so that the year 2000 new car fleet efficiency may be only a

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1. Energy and Environmental Analysis, Inc., Developments in the Fuel Economy of Light-Duty Highway Vehicles. Final Report, contractor report to OTA, August, 1988.

few miles per gallon over today's 28 mpg. Also, if the popularity of light trucks as passenger vehicles continues, it will further decrease prospects for improving the efficiency of the light duty passenger fleet.

- The slowdown in efficiency improvement is particularly worrisome because the demand for travel is likely to continue growing. Vehicle miles traveled (VMT) rose at a rate of 3 percent per year from 1970-1987. During the remainder of the century, VMT will likely continue to grow at between 2 and 3 percent per year...essentially canceling out the potential reduction in oil use from higher efficiency.
- Congress has been given strongly contradictory visions of the potential for improving new car fuel efficiency between now and the year 2000. Advocates for higher fuel economy argue that 45 mpg is a reasonable target for the new car fleet; the industry has argued that future improvements can come only slowly, and that efficiency values much above 30 mpg for the fleet will require technology that is not yet commercial.
- OTA has concluded that the new car fleet could achieve 33 mpg by 1995 by intensifying the use of technologies that are already used in some car models. These technologies will be cost-effective to consumers, but nevertheless they are unlikely to be demanded by consumers or provided by manufacturers without additional incentives. An important caveat to the above conclusion: the achievable fuel efficiency level will be lower if trends towards higher power and towards certain efficiency-reducing options (such as four wheel drive) are not halted.
- The potential for achieving significantly higher levels of fuel efficiency over the longer term appears promising because of the significant number of new technologies under investigation by different segments of the industry. However, the likelihood of successful commercialization, the eventual on-the-road performance achieved, and the costs of these technologies are all highly uncertain.

## *BACKGROUND*

Trends in U.S. oil consumption, production, and imports have worsened over the past few years, adding to concerns about U.S. energy security, balance of trade, and environmental quality. In 1985, the United States was enjoying substantial success in reining in oil consumption, maintaining domestic production, and thus reducing imports. In that year, we produced nearly 9 million barrels per day (mmbd) of crude oil and 11.4

mmbd of total liquid fuels;[2] consumed 15.7 mmbd, down from 18.4 mmbd in 1977; and imported 4.3 mmbd, only 27 percent of total supply, down from a 1977 high of 8.6 mmbd or 46 percent. At the end of 1985, however, world crude oil prices plunged, drastically reducing the incentives for production investments and easing the economic restrictions on consumption. Since 1985, domestic oil production has fallen below 8 mmbd; consumption has risen back over 17 mmbd; and imports have grown to over 6 mmbd in 1988, or 37 percent of total consumption, and are still rising.

These trends have stimulated new interest in the many options available to decrease U.S. oil imports, including stimulation of domestic oil production, the use of alternative fuels, and increased energy efficiency. In addition, measures that increase U.S. energy security by means other than reducing imports -- such as adding to strategic oil reserves, better contingency planning, stimulating non-OPEC oil production, and so forth -- should also be a part of national energy planning.

During the decade and a half since the first oil price shock, the major factor in reducing U.S. oil imports has been the marked reduction in the energy intensity of the U.S. economy, attributable at least in part to dramatic increases in the efficiency of energy use. "Success" in stimulating U.S. domestic production of oil has been measured largely as the ability to stabilize -- not increase -- total production. And while switching to alternative *non-liquid* fuels -- primarily to natural gas and, in the electric utility industry, to coal and nuclear energy as well -- has been successful, alternative *liquid* fuels have played virtually no role. In the future, increased efficiency still appears likely to be the key to any successful effort to reduce U.S. dependency on imported oil.

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[2] that is, crude oil, lease condensate, natural gas plant liquids, processing gains, alcohols, and other liquids.

Because of its importance to U.S. petroleum use, the transportation sector and, particularly, the fleet of light duty highway vehicles, is an important target for further efficiency efforts. In 1988, the transportation sector accounted for approximately 28 percent of the total energy consumed by the United States and, more importantly, 66 percent of all U.S. petroleum consumption. Furthermore, a substantial portion of the remaining oil use involves the consumption of the byproducts of refinery production of transportation fuels.[3]

The light duty highway fleet -- automobiles plus vans and light trucks used largely for passenger travel -- account for a very large portion of U.S. transportation energy use and overall oil use. In 1985, this fleet accounted for fully 39 percent of U.S. oil consumption and 16 percent of total energy consumption. The automobile fleet alone accounted for about 30 percent of U.S. oil consumption and nearly 13 percent of total energy consumption.[4] Consequently, these fleets represent the largest available targets for reducing U.S. petroleum use, and they have in fact become the focal points of recent efforts to involve the federal government more actively in energy efficiency efforts.

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[3] Data from Energy Information Administration, 1989 Annual Energy Outlook, DOE/EIA-0383(89), January 1989.

[4] Data from Oak Ridge National Laboratory and Energy Information Administration.

Proponents of government action to speed conservation efforts have argued that there is an inherent inconsistency in an Administration energy policy that simultaneously urges development of domestic oil resources in wilderness or fragile offshore areas (e.g., the Arctic National Wildlife Refuge, and offshore California) while initiating the rollback of the Corporate Average Fuel Economy (CAFE) standards from 27.5 to 26 mpg.[5] In addition, some energy efficiency analysts have argued that the passenger vehicle fleet could be made far more efficient than today's fleet -- with ultimately an average fuel efficiency of double or even triple current average efficiency -- with readily available technology and at a cost savings over the lifetime of the vehicles. Achievement of such efficiencies could save several million barrels per day in U.S. oil consumption.

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5. These are "nominal" or laboratory fuel efficiency values as measured by the U.S. Environmental Protection Agency. The actual "in-use" efficiencies of new vehicles have tended to be consistently lower -- perhaps 15 percent lower -- than the official EPA mileage figures. The Gas Research Institute assumes that actual in-use mpg is 18.2 percent below the EPA values in their energy forecasts (P.D. Holtberg, et al, Baseline Projection Data Book; 1987 GRI Baseline Projection of U.S. Energy Supply and Demand to 2010, Gas Research Institute.); on the other hand, General Motors claims that the correct factor is less than 15 percent, and will become still lower with time. In any case, the result is that the actual in-use efficiency of today's new car fleet is substantially lower than the value, based on EPA tests, commonly cited. With incorporation of light trucks, the in-use efficiency of today's new passenger vehicle fleet probably is about 21 mpg.

In contrast, many industry analysts deny that the efficiency of the fleet can be improved this readily. They claim that, given the low price of gasoline, the industry has already introduced most of the available marketable efficiency measures into the fleet, and that further improvements will come slowly, at substantial cost, and with substantial uncertainty about performance and consumer acceptability.

Without question, considerable technical potential exists to increase the fuel efficiency of the U.S. light duty passenger vehicle fleet. However, there are strong forces -- economic, technical, and social -- that tend to counteract attempts to increase fleet fuel efficiency. The next few sections will discuss the efficiency and energy use likely to be realized by the fleet if driven only by market forces.

## *MARKET-DRIVEN FUEL EFFICIENCY*

There is widespread agreement among energy analysts that, without significant changes in market conditions or government policy, improvements in the efficiency of the U.S. automobile fleet will slow from their pace of the past decade and a half, with most improvements during the next decade coming from diffusion into the fleet of technologies that are now already introduced into the new car fleet.

The primary factor acting to reduce the potential for rapid increases in fleet fuel efficiency is the lack of strong market pressures for such increases. With lower prices for gasoline (and lower expectations for future price increases), relatively high *non-fuel* costs of operating a vehicle, and average fuel economy of most new vehicles already in the 20-35 mpg range, fuel efficiency has declined dramatically in importance as a factor in choosing a new vehicle. Presuming cost-effective efficiency improvements are available, the overall cost savings over vehicle lifetimes of any efficiency gain will tend to be a small portion of the total costs of ownership and operation.[6][7] Also, many technologies that will improve fuel economy while maintaining performance and other vehicle attributes will cost more than the technologies they replace and thus will likely raise the price of the vehicles. To the extent that automobile purchasers tend to focus on purchase price rather than on "life cycle" savings, high efficiency vehicles may be less marketable than less efficient but lower-priced vehicles.[8]

Available consumer surveys seem to confirm this expectation. The firm of J.D. Power and Associates conducts an annual survey that investigates the factors that consumers consider important in buying their next car. In 1980, when most analysts and consumers held expectations of rapidly escalating gasoline prices, about a third of the consumers surveyed

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6. Assuming that the vehicle interior volume and performance do not change.
7. See, for example, J. Goldemberg, T.B. Johansson, A.K.N. Reddy, and R.H.Williams, Energy for a Sustainable World, World Resources Institute, September 1987.
8. Assuming that the vehicles are otherwise comparable, which they often are not. Note that in today's market, high efficiency vehicles often are "bottom-of-the-line" models that generally are less expensive than alternative models.

listed fuel economy as the most important factor they would consider in selecting their next car.[9] By 1984, ***only 6 percent considered fuel economy as their primary selection factor.***

Other factors that may act to restrain increases in fleet fuel efficiency include:

- Growth in the use of light trucks for passenger travel. Although light truck fuel efficiency has improved markedly since 1974, these vehicles remain substantially less fuel efficient than automobiles. Whereas the average 1987 nominal (that is, laboratory) fleet fuel economy for new automobiles was about 28 mpg, the fleet average for new light trucks was closer to 21 mpg[10]. This disparity in efficiency between autos and light trucks has a growing influence on the overall efficiency of the "light duty" fleet because the passenger use of light trucks is growing far more rapidly than auto use. Light truck VMT grew at a rate that was over 5 times that for autos between 1970 and 1985; during this period, auto VMT grew 38 percent while light truck VMT tripled.[11] And according to 1985 Census data, light trucks are now being used more as passenger vehicles than as freight haulers, making them legitimately part of a light duty passenger fleet.

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[9] J.D. Power and Associates, The Power Newsletter, Westlake, California, as reported in Patterson, P.D., ......

[10] Up from about 12 mpg in 1974.

[11] Patterson, P.D., "Analysis of Future Transportation Petroleum Demand and Efficiency Improvements," IEA Energy Demand Analysis Symposium, Paris, France, October 12-14, 1987.

The difference between light truck and auto efficiency pulled the overall (nominal) new light duty fleet average down to about 25 mpg, and is likely to continue to hold down fleet averages in the future. The growing role of light trucks in passenger travel is a primary cause of the recent stagnation in the fleetwide average fuel economy of new light duty passenger vehicles, which has increased only 1.4 mpg since 1981; the larger numbers of light trucks in the fleet provided a counter to efficiency gains within each portion of the fleet.

- A growing attraction among purchasers of new automobiles to more powerful (and thus less fuel efficient) automobiles. For example, the average 0-60 mph acceleration time for new vehicles has decreased in every year since 1982. Part of this trend is simply a recapture of performance levels lost earlier to emission control and satisfaction of CAFE standards; strong consumer objections to reduced power levels were raised by consumers in the early 1980s. Although the preference for increased performance may well disappear in the future, it is worrisome to those concerned with fuel conservation. An important consequence of this consumer preference is that drive-train improvements (such as engines with four valves per cylinder and turbochargers) with the potential to either increase fuel efficiency or boost horsepower from previous levels have been introduced in configurations that emphasize power increases rather than fuel savings.

There is not a precise formula to define the relationship between power and fuel economy. One examination of performance data for different models of the same car, with different performance, found that fuel economy is roughly proportional to the square-root of acceleration time. This relationship implies that the reduction in average acceleration time from 14.4 seconds in 1982 to 12.9 seconds in 1987 caused a decline in the fuel economy of new 1987 cars from a hypothetical 29.6 mpg (had performance remained the same) to the actual 28.0 mpg. Another analysis found that the effect of the 1982-1987 performance gain was a 3-4 percent decline in fuel economy -- about 1 mpg, or from about 29 mpg to the actual 28.0 mpg.[12]

- **Additional luxury and safety equipment on new cars.** Although air conditioning and power steering have penetrated over 8. percent of the fleet, and further increases will be small, other equipment such as power seats, sunroofs, and power locks and windows may gain additional market share and can add significant weight to the vehicle. In addition, four-wheel drive, which may add 150-200 pounds to a vehicle and cut its fuel economy by 12-15 percent, is gaining in popularity. And safety equipment such as air bags (30-45 lbs.) and anti-skid brakes (30-45 lbs) will add further weight. The net effect of greater penetration of these technologies could be as large as a 3-5 percent decrease in fuel economy.[13]

- **More stringent emission standards, especially for nitrogen oxides.** If proposed new federal standards on exhaust and evaporative hydrocarbons and nitrogen oxides are enacted, manufacturers will choose from alternative strategies that will trade off cost, fuel efficiency, and emissions. There are approaches available to the the manufacturers -- for example, increasing the rhodium content of vehicle catalyst systems -- that would allow a more stringent nitrogen oxide standard to be met with no fuel economy penalty, but at an added cost. On the other hand, if the manufacturers perceive that consumers do not value fuel economy highly, they may choose control strategies that add little or no cost but sacrifice some fuel economy. In addition, the manufacturers could choose to add technologies that have potential for both efficiency improvement and emission control -- such as multipoint fuel injection -- in ways that maximize the emission reduction effects but sacrifice some of the efficiency potential. In these cases, the emission standards would have caused some potential improvement in fuel economy to be foregone. Historically, manufacturers have pursued a variety of strategies to achieve previous standards: to meet the 1981 emission standards, many Japanese manufacturers chose to use oxidation catalyst technology and accepted an efficiency loss of 6 to 8 percent; General Motors met the same standard with "closed loop" electronic fuel control systems with three-way catalysts that incurred no efficency loss.[14] EEA has estimated the potential fuel economy penalty (or gain foregone) of the proposed .4 grams/mile standard for nitrogen oxides to be 2-4 percent *if the manufacturers choose to sacrifice efficiency in order to minimize costs*.[15]

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[12] Energy and Environmental Analysis, op cit.
[13] Energy and Environmental Analysis, op.cit.

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[14] Energy and Environmental Analysis, Inc., op.cit.

[15] Ibid.

- **Slower replacement of the automobile fleet, so that technological improvements introduced into the new car fleet will take longer to diffuse into the total fleet.** Whereas in 1969 cars more than 10 years old accounted for only about 7 percent of vehicle miles traveled (VMT) and fuel consumed, by 1977 these older vehicles accounted for about 13 percent of VMT and fuel, and by 1983 they accounted for almost 20 percent of VMT and 23 percent of fuel.[16]

- **No signs that U.S. drivers will shift to smaller cars.** Although average *exterior* size and vehicle weight have been reduced substantially -- with great positive effect on fuel efficiency -- the average interior volume of new automobiles in the U.S. fleet has remained virtually constant for 10 years: it was 109 cubic feet in 1978, and 108 in 1987. On the other hand, the vehicles often cited as demonstrating the potential for major fleet efficiency improvements -- the very high efficiency vehicles in the current fleet and most of the ultra high efficiency prototypes -- are smaller. Although substantial efficiency gains can be made without a shift to smaller cars -- only about one tenth of 1978-1984 progress in new car efficiency was due to shifts to smaller cars[17] -- the apparent inability to effect such a shift remains costly to prospects for future gains.

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[16] U.S. Department of Energy, Assessment of Costs and Benefits of Flexible and Alternative Fuel Use in the U.S. Transportation Sector. Progress Report One: Context and Analytical Framework, DOE/PE-0080, January 1988.

[17] Patterson, P.D., "Trends in Automobile Fuel Economy and Energy Use," ORSA-TIMS Conference, Boston, MA, April 30, 1985.

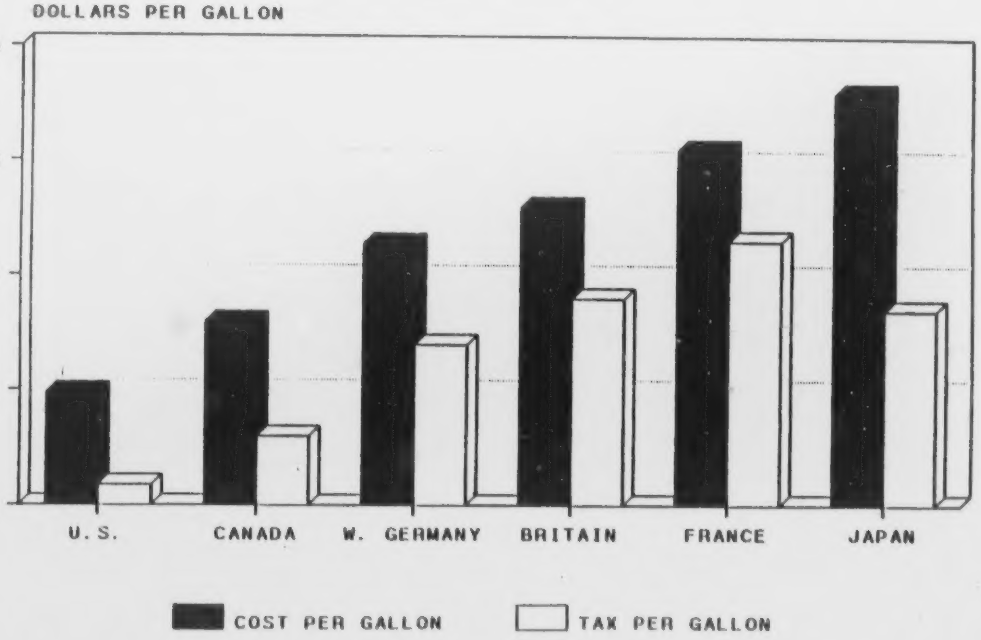
- **Continued consumer demand for "old-fashioned" car models.** U.S. manufacturers have found that a portion of new car purchasers prefer large, heavy, rear-wheel drive models even though newer, more fuel-efficient designs appear to be functionally superior. Because the manufacturers can obtain high profit margins on these models, they have kept them in the fleet despite prior plans to phase them out.

If current low oil prices persist, the relatively modest benefits to the individual automobile owner of improving fuel efficiency beyond about 30 mpg are unlikely to provide much incentive to manufacturers who must factor in both market risk and the risk of reliability problems into their design and marketing decisions. Manufacturers are likely to be extremely reluctant to introduce a major new fuel-efficient technology unless it offers other important benefits as well. Some possible side benefits include better emission control characteristics (e.g., from better combustion controls, or merely from the smaller mass of fuel burned per mile) and improved performance (e.g., from introducing continuously variable transmissions). However, despite the existence of some side benefits, improvement in new car fuel economy is expected to be incremental in nature and quite slow as long as the current market environment persists.

Thus, the future course for the U.S. new vehicle fleet -- absent sharp increases in world oil prices or policy intervention such as gasoline excise taxes (which amount to over $2/gallon in many other industrial countries; see Figure 1) or tightening of CAFE standards -- appears to be

FIGURE 1

GASOLINE COST WITH TAX



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only modest additional increases in fuel efficiency as engineering improvements that are well along in development gradually are introduced. With such technological and design improvements, and, above all, with the gradual retirement of older, less efficient vehicles, the fuel economy of the entire passenger vehicle fleet will continue to rise during the remainder of this century.

Projections of both new car and light duty fleet fuel economy beyond a few years from today are at best educated guesses, and should be treated as such. Some recent projections include:

- The Energy Information Administration's projection for year 2000 new automobiles is 34 mpg (EPA), for new light trucks, 25.3 mpg, and for the entire light duty fleet, 24 mpg (in-use).[18]

- Energy and Environmental Analysis's projection for year 2000 new automobiles is 31.3 mpg (EPA), for new light trucks, 23 mpg, and for the entire light duty fleet, 22.2 mpg (in-use).[19]

- Data Resources, Inc.'s projection for the year 2000 *domestically produced* new automobiles is 30.1 mpg (EPA).[20] This average would be expected to be slightly less than the average for the entire fleet.

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[18] Energy Information Administration, 1989 Annual Energy Outlook

[19] Energy and Environmental Analysis, Inc., The Motor Fuel Consumption Model, Fourteenth Periodical Report, Draft, for Martin Marietta Energy Systems, Inc., December 6, 1988.

[20] Data Resources, Inc., Energy Review, Winter 1988-89.

Vehicle fuel efficiency could, of course, easily be somewhat higher or lower than these projections. For example, a combination of factors -- additional safety equipment added, continued increases in vehicle performance, more stringent emission standards that are met by least-first-cost (but fuel inefficient) measures, continuation of trends in imports towards larger and more luxurious (and powerful) vehicles, and growing market share for vans and light trucks -- could make it difficult for the new vehicle fleet to improve significantly beyond today's level. Yet a renewal in consumer and public policy interest in fuel economy could cause fleet efficiency to rise above the projected levels by a combination of shifts in market shares of alternative models, more rapid diffusion of existing technology into the fleet, and an acceleration of the introduction of new technologies.

OTA believes that a likely fuel economy value for the components of the new vehicle fleet in the year 2000, given current trends and no radical changes in either government policy or fuel prices, would lie in the same range as these projections, although we feel that the EIA value is somewhat optimistic. A reasonable mid-range value is about 32 mpg (EPA) for automobiles and 24 mpg for light trucks, yielding an overall light duty new vehicle fleet average of about 29 mpg.[21] The corresponding *in-use* average of the entire light duty fleet would be about 22-23 mpg.[22]

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[21] Assuming that light trucks account for about one third of the new light duty fleet.

[22] The values for the overall fleet are calculated by assuming that the in-use efficiency is about 80 percent of the nominal (85 percent is widely used for autos, but the conversion factor is considerably lower for light trucks).

***TRAVEL DEMAND***

The likelihood that the market will act to slow down improvements in fleet efficiency is particularly worrisome to energy policy analysts because the complementary component of oil use -- the vehicle miles traveled (VMT) -- is expected to continue to rise. The rate of increase in vehicle miles traveled between 1970 and 1987 was very large -- about 3 percent per year. For the remainder of the century, the rate of increase is likely to be smaller for demographic reasons, but there is considerable uncertainty, and quite conceivably the rate of increase could remain high.

As shown in Figure 2, the rise in VMT over the past several decades has been almost constant, as expected "saturation points" in auto ownership and travel demand did not occur. Initial assumptions that vehicle saturation would occur at 1 vehicle per household were surpassed in the United States in the 1930s. Then, a proposed saturation point of 1 vehicle per worker was surpassed in the mid-1960s. Expected saturation of 1 vehicle for each licensed driver was surpassed in 1983.[23] And for the past 30 years, VMT per vehicle has remained at about 10,000/year, driving total U.S. VMT upwards at the rate of expansion of the fleet.[24] The year-by-year rise in travel faltered only twice, and then only for very brief periods when gasoline supply problems were coupled with very sharp price increases.

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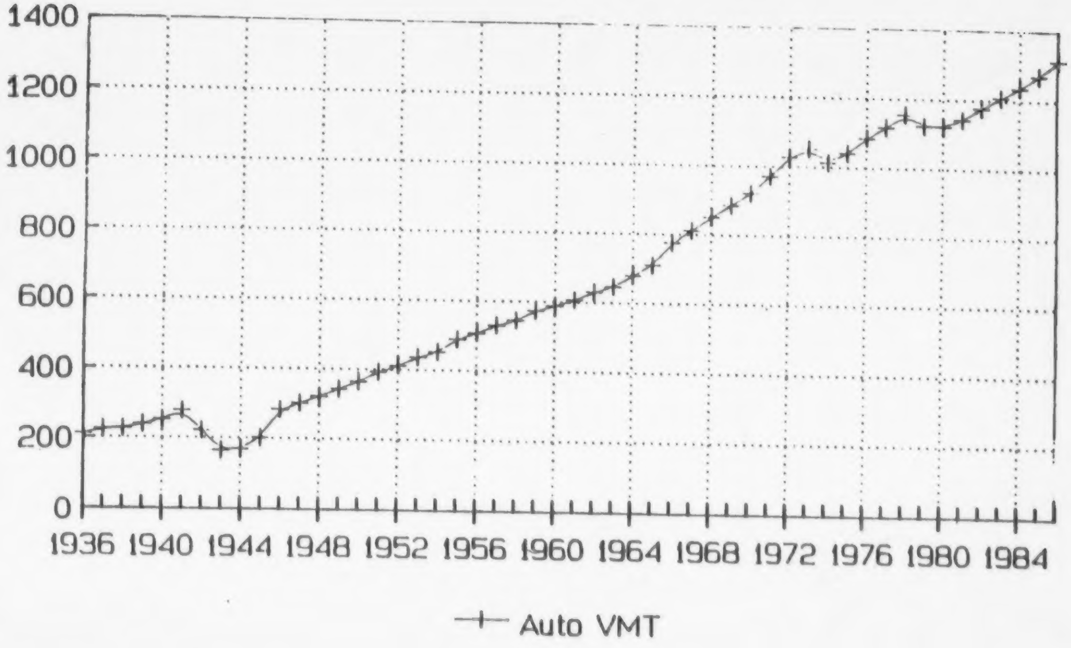
23. Patterson, P.D., "Analysis of Future Transportation Petroleum Demand and Efficiency Improvements," IEA Energy Demand Analysis Symposium, Paris, France, Oct 12-14, 1987.
24. Ibid.

FIGURE 2

U.S. AUTO FLEET TRAVEL
(vehicle miles travelled, vmt)



Source: Dept. of Transportation.
FHA. Highway Statistics Summary to 1985.
FHA. Highway Statistics 1986.

More than half of the increase in VMT over the past 15 years can be attributed to the increase in the number of adults of driving age; the remainder was due to the growth in driving per licensed driver and the higher proportion of licensed drivers in the population -- the latter due largely to the growth of women in the workforce.

The Energy Information Administration's recent 1989 Annual Energy Outlook[25] projects personal travel by autos and light trucks to grow at 2.1 percent/year for the 1988-2000 period, reflecting their judgment that the market for such travel will slow somewhat from its steady rate of the past few decades. Other recent forecasts by Argonne National Laboratory, Energy and Environmental Analysis, Inc., and the Federal Highway Administration[26] show 1985-2000 growth rates for the light duty fleet of 2.27 percent, 2.75 percent, and 2.13-3.14 percent, respectively -- higher than EIA's rate but also generally below the recent trend.

OTA agrees that a decreased growth rate for travel is likely. However, there is considerable room for argument about the likelihood of a decrease, especially because of the stability of vehicle mileage trends in the past. Factors that will affect future VMT include:

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[25] Energy Information Administration, 1989 Annual Energy Outlook, DOE/EIA-0383(89), January, 1989.

[26] The first two forecasts are described in Patterson, P.D., "Analysis of Future...," op.cit. The growth rates were calculated from data obtained from the author. The last forecast is from Federal Highway Administration, The Future National Highway Program, 1991 and Beyond. Working Paper No. 2, Trends and Forecasts of Highway Passenger Travel. October 1987. For this last forecast, the cited growth rates are actually for 1983-2005.

**women in the workforce.** During the past few decades, the growing share of women working, and therefore needing to commute, has contributed significantly to rising levels of light duty vehicle travel. Between 1969 and 1983, the percentage of adult women in the workforce rose from 39 percent to 50 percent, and of those working, the percentage with drivers licenses rose from 74 percent to 91 percent. Further increases in the share of women working will continue to affect the demand for transportation services during the next few decades, but *probably* at a slower rate because the current percentage of working women is now high. However, women, working or not, still do not drive nearly as much as men; this leaves open the possibility that future shifts in lifestyles among women could drive VMT at a higher rate than predicted.

**number of adults.** The rate of growth of adults of driving age will slow as the baby boom passes. After 2000, however, the rate of increase will depend on future birth rates, which are uncertain.

**possible saturation among high mileage drivers.** Employed men between 25 and 54 years of age drive more than any other large group -- about 18,000 miles per year. This represents an average of 1.5 hours per day spent driving. Although "common sense" about saturation of driving has been wrong before, it is at least possible that this group may be nearing saturation.

changing economic structure. The growth in part time work and the shift in the economy towards more services may lead to increased driving, by bringing more individuals into the workplace and by increasing delivery requirements. The potential for delivering certain types of services, especially information, electronically may eventually substitute for some transportation, but thus far such trends have not been observed.

traffic congestion. The increasing congestion of metropolitan areas will alter travel patterns. Congestion will decrease the fuel efficiency of those trips that are made; discourage other trips (or shift them to public transportation, or to the electronic media where possible); encourage some people to work closer to home or move closer to work; and encourage businesses to move to the less congested fringes, increasing travel requirements. The net effect on fuel demand is unpredictable.

In OTA's view, the most predictable aspects of the above factors are the lower number of persons reaching driving age and the likely slowdown of the effects of women entering the workforce, both acting to slow the growth in VMT. Nevertheless, the uncertainty associated with the various factors affecting travel demand probably allows a range of feasible growth rates of 2-3 percent *without* considering the potential for future price shocks. An unexpected large increase in gasoline costs, or supply problems, could cause the growth in personal travel demand to fall below these levels, or even to go negative.

*LIGHT DUTY FUEL USE*

*The effect of a combination of moderate improvements in vehicle efficiencies and a steady but slightly slower increase in miles driven -- which OTA considers the most probable future for personal highway travel during the next decade -- will be that, absent policy changes, the fuel consumption of the passenger vehicle fleet is likely to change little between now and 2000; the expected efficiency improvements will approximately offset the expected increase in miles driven.*

To be more precise, the fuel efficiency and vehicle miles traveled projections of the Energy Information Administration and Energy and Environmental Analysis, Inc., cited above, imply that year 2000 fuel use by autos and light trucks combined will be, respectively, 2.6 or 2.2 percent higher than today's. This is a very small change for an 11 year period.

A projection of stagnant automotive fuel consumption is quite in line with the experience of the past decade and a half. Between 1973 and 1987, the in-use fuel economy of the U.S. automobile fleet improved from about 13.3 mpg to 18.2 mpg; light truck fuel economy improved sharply, as well. In 1987, this improvement amounted to a savings of about 1.8 mmbd over what oil consumption *would have been* had 1987 driving levels been accomplished with 1973 fleet efficiency (at about $1.00/gallon, this equates to an annual savings to U.S. drivers of close to $30 billion per year);[27] because mileage driven increased substantially during this period, the actual petroleum consumption of the fleet changed little, rising from 5.41 mmbd in 1973 to 5.70 mmbd in 1987.

Of course, alternative projections differ somewhat about this. For example, a recent Chevron forecast (World Energy Outlook, October 1987) projects a decrease in gasoline usage of 0.3 percent per year to the year 2000, whereas Conoco (Energy Outlook Through 2000, September 1987) projects a 0.5 percent per year *increase* in gasoline demand through 2000.

## *THE POTENTIAL FOR STIMULATING HIGHER LEVELS OF FUEL EFFICIENCY*

Despite the forces exerting upward pressure on gasoline consumption, there clearly are a variety of technological and design changes that could substantially raise the fuel economy of the passenger vehicle fleet, and some of these will be cost effective even at current low gasoline prices. The disappointing *market* prospects for future improvements in passenger vehicle fuel efficency, discussed above, imply that there may be considerable technological "headroom" -- and potential for shifts in the mix of vehicles purchased -- that can be captured with non-market solutions (regulation) or additional market incentives. In other words, additional fuel savings can be achieved with fuel taxes, fuel economy standards, or

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27. Depending on assumptions, the magnitude of the savings can be somewhat different. For example, a recent World Resources Institute report (J. Goldemberg, et al, Energy for a Sustainable World, September 1987) calculates the savings for 1975-1985 -- a shorter time period -- to be 2.4 mmbd. Although the difference is substantial, the point remains the same.

other policy mechanisms encouraging increased efficiency, although there is substantial controversy about the likely magnitude and timing of fuel savings, the costs, and the effects on the industry.

### *Arguments of the Energy Conservation Community*

Analysts from the energy conservation community can marshall a variety of arguments to support the proposition that the efficiency of the U.S. light duty new car fleet can be greatly increased over the next 20 years.[28] First, because market pressures have held down gains in fleet efficiency during the 1980s, they argue that government action to change market pressures could reverse this trend. In particular, lower gasoline prices reversed previous trends towards smaller cars and dropped the market shares of fuel efficiency leaders such as the Rabbit diesel. Presumably, government actions to raise gasoline prices, raise the purchase price of fuel-inefficient vehicles, and possibly lower the purchase price of fuel efficient vehicles could substantially increase fleet efficiency even without the introduction of new technologies, by encouraging purchasers to buy cars in lower size classes and/or the more fuel efficient models in each size class, and encourage manufacturers to use available fuel efficiency technologies more widely in their fleets. In the longer run, these actions would encourage manufacturers to develop new technologies and consumers to purchase them.

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[28] See F. Von Hippel and B. Levi, "Automobile Fuel Efficiency: the Opportunity and the Weakness of Existing Market Mechanisms," Resources and Conservation, pp. 103-124, 1983, and Bleviss, D.L., The New Oil Crisis and Fuel Economy Technologies: Preparing the Light Transportation Industry for the 1990s, Quorum Books, 1988.

Second, the conservation community claims that a variety of fuel efficiency technologies exist today, in fully commercialized form, that are not as widely disseminated through the fleet as they could be. Table 1 lists a number of technologies whose introduction or wider use offer a potential to improve fleet fuel efficiency.

Third, several car manufacturers have produced vehicle prototypes that are reported to achieve very high fuel efficiency (see Table 2). The conservation analysts contend that the existence of these prototypes provides concrete evidence of the high long-term potential for improving fleet efficiency.

Finally, a variety of new technologies at various stages of development have been identified that appear to show promise of achieving large efficiency gains. For example, new designs of a two-stroke engine for automobile applications have been said to be capable of achieving fuel economy gains of 20 percent or more over conventional four-stroke engines with concurrent reductions in manufacturing costs.[29] Other engine designs said to hold considerable promise include direct-injection diesels and adabiatic diesels. Table 3 lists some of the potential efficiency technologies. Advocates of higher fuel economy standards and other

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29. "Detroit Gets Serious About Two-Stroke Engines," Business Week, July 18, 1988. Also, see Plohberger, D., Mikulic, L.A., and Landfahrer, K., "Development of a Fuel Injected Two-Stroke Gasoline Engine," SAE Technical Paper Series *880170, 1988.

Table 1. Reported Efficiency Improvements for Developed or Near-Term Technology

| Technology | Percentage Improvement Over 1987 Base[1] | |
|---|---|---|
| | EEA[2] | Industry[3] |
| Engine Improvements[4] | | |
| 4 valve per cylinder | 10.0/5.0 | 4-5 or less |
| Overhead camshaft | 6.0 | low |
| Roller cam followers | 1.5 | 0.5-4.0 |
| Low friction rings/pistons | 1.5 | |
| Throttle body fuel injection | 3.0 | 0-3 |
| Multipoint fuel injection | 7.0 | 4 |
| Intake valve control | 4.0 | 1-2 |
| Four speed automatic transmission | 7.5 | 5-6 |
| Electronic transmission control | 1.5 | low |
| Aerodynamics, $C_D = 0.34$ | 3.4 | 3 |
| Tire improvements | 0.5 | |
| Lubricants (5W-30) | 0.5 | |
| High efficiency accessories | 1.0 | |

Notes: 1. Values may not be additive.

2. Energy and Environmental Analysis, Inc., Developments in the Fuel Economy of Light-Duty Highway Vehicles, contract report to OTA, August, 1988, with minor revisions.

3. Based on comments received in review of the EEA draft report and at an OTA workshop on automotive fuel economy, September 14, 1988.

4. Because newly designed engines all have multiple improvements, the efficiency improvements represented by individual design changes are not easily separable.

Table 2. High Efficiency Automobile Prototypes

| Prototype | Fuel | Fuel Economy (miles per gallon) | Passenger Capacity (persons) |
|---|---|---|---|
| VW Auto 2000 | diesel | 66 | 4-5 |
| Volvo LCP 2000 | multifuel | 69 | 2-4 |
| Renault EVE+ | diesel | 70 | 4-5 |
| Toyota Ltwght Compact | diesel | 98 | 4-5 |

Notes: fuel economies converted to equivalent EPA test values, using conversion factors recommended by the International Energy Agency. Details, and further descriptions of the vehicles are in the source document. Vehicles do not necessarily meet all U.S. emissions or safety requirements.

Source: Table 10. Fuel Economy for Passenger Automobiles, in J. Goldemberg, et al, Energy for a Sustainable World, World Resources Institute, September 1987.

**Table 3. Future Technologies for Improving Light Duty Vehicle Efficiency**

*Variable-Geometry Turbochargers.* Increases effectiveness of turbocharging at low loads, allows engine downsizing.

*Improved electronic controls.* Adjustment of engine operating parameters (e.g., ignition timing) based on direct measurement of cylinder pressure and other operating conditions.

*Condenser engine cooling.* Allows fast warm-up, reduced coolant yields reduced weight.

*Advanced lubricants (solid and gaseous).*

*Oxygen enrichment of air intake.* Using membrane technology to enrich oxygen content of intake air, effect similar to but more effective than turbocharging.

*Adiabatic diesel.* Low heat rejection engine achieved by heavy use of ceramics. Couples removal of cooling requirement and capture of exhaust energy through turbocharging or supercharging.

*Continuously variable transmissions.* Allows engine to be kept at optimum operating speed throughout the driving cycle. Currently available for small engines only.

*Advanced materials.* Obtaining substantial weight reduction through use of improved plastics and further use of high strength steels, aluminum, magnesium, ceramics.

*Advanced tires.* Reductions in rolling resistance through improvements in design and/or use of advanced materials, e.g. liquid-injection-molded polyurethane.

*Engine stop-start and energy storage.* Engine shut-down during idle and braking, coupled with flywheel storage to power accessories and aid restart.

Source: Bleviss, D.L., The New Oil Crisis and Fuel Economy Technologies, Quorum Books, 1988.

efficiency-oriented policy actions believe that such measures will speed up development and introduction of these new technologies.

Analysts associated with the American Council for an Energy Efficient Economy have recently proposed a year 2000 efficiency goal for new vehicles of 45 mpg (EPA) for autos and 35 mpg for light trucks[30]. Achieving these goals would raise average in-use fleet mileage to about 27 mpg by 2000, up from a projected level of about 22 mpg. If total annual mileage traveled were 2.21 trillion miles, this efficiency improvement (27 vs. 22 mpg) would save about 1.2 mmbd of oil or, at $1.00/gallon, over $20 billion per year by 2000, and more in future years as the technology diffused into the fleet. The energy conservation community argues that these goals are both technically achievable and cost-effective even at today's gasoline prices, based on available vehicle prototypes and cost and performance analyses for a variety of individual technologies.

### *Industry Arguments*

Industry analysts argue strongly against claims that the new car fleet fuel efficiency can readily be increased this much. For example, they argue that the performance of the technological improvements added to the fleet during the past decade, while impressive, still fell short of

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30. Chandler, W.U., Geller, H.S., and M.R. Ledbetter, Energy Efficiency: A New Agenda, American Council for an Energy Efficient Economy, Washington, D.C., July 1988. The authors suggest several policies to complement and help achieve this goal, including gasoline taxes, new "gas-guzzler" taxes, and a "gas-sipper" rebate program. They also suggest that efficiency standards be carefully structured to avoid past problems of unfairness, for example, by basing them on vehicle interior volume.

projected levels. They reject many of the efficiency improvement projections for fuel efficiency technologies claimed in the energy conservation literature, noting that the process of moving from the laboratory and test track to the fleet involves numerous engineering compromises to allow reliable and efficient manufacture and practical servicing of the technology. They also argue that many of the projections of high fuel efficiencies associated with the use of multiple technologies involve substantial "double-counting." They stress the difference between "technical availability" and "marketability," noting that many available technologies -- such as diesel engines -- have proved effective at increasing fuel efficiency but have been soundly rejected in the marketplace because of their failure to match other market requirements. Further, they argue that the many confident predictions of imminent introduction of new technologies fail to consider the difficult remaining technical problems that may slow or even prevent these technologies from being introduced (for example, they are concerned that two stroke engines will have difficulty in meeting emission standards for nitrogen oxides). And they are skeptical of the importance of high mileage prototypes in predicting market potential, arguing that these vehicles are designed solely to achieve high efficiency and could not realistically compete in the marketplace. Finally, they claim that a number of government regulations, in particular those on emissions and vehicle safety, as well as current marketplace interest in greater power and more luxury equipment, will act counter to attempts to improve fuel efficiency. Thus, at least part of any efficiency improvements added to the fleet will act to nullify the effects of these factors rather than actually raising fleet efficiency from present levels. The industry claims that their experience in the 1980s with efficiency improvements implies that it is *not* feasible to attain the efficiency goals advocated by the conservation community.

Industry analysts and others have also warned that a strong government push for increased levels of fuel economy could have strongly adverse effects on traffic safety. The industry claims that requirements for large improvements in fleet fuel efficiency will push the new car fleet towards smaller vehicles, because only substantial reductions in average vehicle size will allow such improvements. Because the industry believes that small vehicles are less safe than large vehicles, they believe that traffic injuries and fatalities would increase as a result of stringent new fuel efficiency standards.

### *OTA Analysis and Conclusions*

After examining these various arguments, OTA has come to the following conclusions:

A. Differing assumptions between antagonists. ***OTA concludes that at least part of the disagreement about achievable fuel efficiencies between the industry and the energy conservation community stems from different marketplace assumptions rather than technical disagreements.*** In many instances, the conservationists advocate fuel efficiency goals that they recognize would require, for successful implementation, a change in market incentives -- a tax on gasoline, rebate on fuel efficient models, etc. -- as well as more stringent efficiency standards. The industry, concerned primarily with consumer acceptance, generally discusses efficiency potential presuming that market incentives do not change, and thus arrives at more pessimistic conclusions.

B. Technical disagreements about long-term technologies. Regardless of different market assumptions, however, there remain strong technical disagreements about the availability, performance, cost, and other effects of fuel efficiency technologies.

***Those disagreements about technologies that are not yet in mass production are extremely difficult -- in some cases, impossible -- to resolve at this time.*** However promising some advanced technologies may appear, their costs and performance will be highly uncertain until they are fully developed and in mass production and use. Similarly, the performances of "one of a kind" vehicle prototypes are instructive but far from conclusive in determining market acceptability. In a previous study, OTA concluded that increases in fuel efficiency to very high values "involve significant technical and economic risks," and an "increased risk that...insufficient development and testing will lead to poor on-the-road performance and/or product recalls."[31] In addition, OTA concluded in that study that the consumer costs of increased fuel efficiency, measured in dollars per gallon of gasoline saved, are quite speculative. For example, OTA's estimate of the consumer costs (in 1982 dollars) to achieve an average new-car fuel efficiency of 38-48 mpg varied from $.35/gallon saved to as high as $2.60/gallon saved.[32] These estimates range from economically attractive costs to costs that will be unacceptable to new car purchasers without large increases in gasoline prices.

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[31] Office of Technology Assessment, Increased Automobile Fuel Efficiency and Synthetic Fuels: Alternatives for Reducing Oil Imports, September 1982.

It is, however, widely acknowledged in the automotive engineering community that there are a wealth of interesting automotive technologies under development whose successful introduction into the fleet would have significant positive impacts on fuel efficiency (See Table 3). Although the cost, performance, and market acceptability of each technology may individually be highly uncertain, it is fair to assert that ***broad, aggressive development programs undertaken by the industry would stand a good chance of successfully moving some of these technologies into the fleet. It is also clear, however, that current market incentives do not encourage such programs.***

C. Fuel efficiency improvements from already-available technologies. Shorter term improvements involving technologies already in mass production are easier to evaluate. Based on our current analysis, ***OTA concludes that the new car fleet can be made significantly more efficient, without sacrificing performance, by adopting technologies that are already available in the marketplace and that have gained a***

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[32] Ibid. The cost range reflects an assumed moderate shift towards smaller cars. Costs to attain the same efficiency range with no shift in car sizes (interior volumes) presumably would be higher.

***measure of market acceptance.*** For example, comparisons among cars with virtually identical physical and performance characteristics but with different engine designs show that some of the newer engine designs available today -- such as General Motors' 4-valves-per-cylinder "Quad4" engine -- can boost fuel economy by about 10 percent on these models.[33] Ironically, these examples may be among only a very few where 4-valves-per-cylinder engines have been used as an efficiency measure. In most cases where such engines have been introduced, they have replaced conventional (2-valves-per-cylinder) engines of similar displacement, with an ***increase in power rather than improved fuel efficiency.***

Assuming market conditions do not change substantially, the average fuel economy of the new car fleet is likely to be about 30 mpg (EPA) by 1995 -- and perhaps less. ***OTA believes that the 1995 new car fleet average could be close to 33 mpg if the industry began, right now, to plan to move available fuel efficiency technology into the fleet at a more rapid pace. We calculate that this level of efficiency could be obtained without a performance loss or the need to move to smaller vehicles, at a cost that would be compensated for by fuel savings.***[34] ***However, this "cost effectiveness" does not guarantee market***

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[33] For example, the Pontiac Grand Am with the Quad4 obtains 32.2 mpg (EPA combined city/highway) versus 26.3 mpg for the virtually identical Chevy Beretta with conventional 2-valves-per-cylinder (and lower horsepower) engine. About half of the savings is due to a basic modernization of the engine, since the original engine is an older model; the other half is due to shifting from 6 cylinders to 4 and to reducing engine displacement, both allowed by the use of 4 valves per cylinder.

[34] Assumptions: 1995 gasoline prices at $1.10/gallon in 1987 dollars; discount rate of 10 percent; gasoline savings counted over only the first four years of driving.

***acceptability, because other factors -- first cost of the vehicle, increased performance, driving "feel," and other factors -- may in sum be considerably more important than life cycle costs in influencing new car buying decisions.*** Thus, ***OTA doubts that the industry will pursue this course without a further economic or regulatory incentive to do so.*** Also, ***this goal is unlikely to be reached unless current trends towards increased performance and luxury (including increased use of 4-wheel drive) cease, and unless industry can -- and will -- comply with any new emission standards by choosing technologies that do not reduce fuel efficiency.***

Table 4 presents the technical means by which the automobile industry might achieve a 1995 new car fuel efficiency level of 33 mpg. OTA recognizes that there is disagreement about the actual performance that will be achieved by some of the technologies listed in Table 4. Some of these disagreements surfaced during a review of OTA draft publications, and others during a workshop on fuel efficiency technologies held by OTA last September. In particular, some industry analysts claimed that the efficiency improvement estimates in Table 4 for front-wheel drive, four speed automatic transmissions, electronic transmission control, and fuel injection were too high -- for front-wheel drive, substantially too high. Also, some analysts claimed that there was some double-counting in the estimates.

Because fuel efficiency improvements have generally not been introduced one-at-a-time, and are rarely available as options, there are few opportunities to separate out their individual contributions to efficiency by a simple examination of the differing fuel efficiencies of

## TABLE 4

## BASE CASE 1995*
(Free Market Scenario)

1987 Base Fuel Economy 28.0 mpg

| Technology | % F/E Gain | % Market Penetration 1987 | % Penetration Increase 1987-1995 | Fleet % F/E |
|---|---|---|---|---|
| Front-wheel drive | 12.0 | 78.0 | 10 | 1.2 |
| 4-cylinder/4-valve** | 10.0/5.0 | 5.0 | 40 | 3.0 |
| Four-speed automatic/CVT | 7.5 | 35.0 | 40 | 3.0 |
| Electronic transmission control | 1.5 | 2.0 | 80 | 1.2 |
| Aerodynamics ($C_D$ from 0.37 to 0.32) | 3.4 | N/A | 100 | 3.4 |
| Tires | 0.5 | N/A | 100 | 0.5 |
| Accessories | 1.0 | N/A | 100 | 1.0 |
| Engine improvements | | | | |
| - Overhead cam engines | 6.0 | 40.0 | 20 | 1.2 |
| - Roller cams | 1.5 | 40.0 | 40 | 0.6 |
| - Low friction rings/pistons | 1.5 | N/A | 80 | 1.2 |
| - Throttle body fuel injection | 3.0 | 31.0 | 10 | 0.3 |
| - Multipoint fuel injection | 7.0 | 45.0 | 10 | 0.7 |
| Total | | | | 17.3 |

1995 Fuel Economy = 32.8 mpg

N/A - Not applicable.

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* Effect of increased luxury/performance not considered in this table. Actual fuel economy could be 3 mpg lower depending on economic conditions

** The large fuel economy gain is associated with a 6-cylinder or 4-cylinder engine replacing an 8-cylinder or 6-cylinder engine (respectively) of equal power. The smaller gain is associated with engines of equal power and equal number of cylinders, but different displacement.

TABLE 4 - CONTINUED

| Technology | Base Technology | Comment |
|---|---|---|
| Front-wheel drive | Rear-wheel drive | Assumes constant interior room |
| Aerodynamics II | 15% drag reduction from 1987 base $C_D = 0.37$ | Assumes drivetrain adjustment to capture benefit |
| Four-speed automatic | Three-speed automatic | Assumes no change in performance in lower gears |
| Electronic transmission control | Mechanically controlled transmission | Assumes shift points optimized for FTP |
| Tires | Improved rubber formulation and design | Evolutionary improvements |
| Accessories | Two-speed accessory drives improved pumps, etc. | Combination of evolutionary improvements and new technology |
| Four-cylinder/4-valve | Four-cylinder, 2-valve overhead cam engine | Engine downsized for constant performance |
| Overhead cam | Pushrod (overhead valve) engine | Engine downsized for constant performance |
| Roller cam follower | Sliding cam follower | Benefits up to 4% demonstrated |
| Low friction rings and pistons | Low tension rings and low mass pistons | Includes effects of better manufacturing |

otherwise identical vehicles. However, OTA is satisfied that its estimate of the aggregate effect of multiple technologies is accurate, and we believe the estimates of the individual technologies are accurate as well, although to a lesser degree of confidence. Checks of actual vehicles with similar physical characteristics (weight, performance) but different drivetrain combinations and differences in other efficiency-affecting characteristics have tended to confirm these estimates. However, if the OTA estimates do turn out to be somewhat optimistic, there are other technologies available, and opportunities for further market penetration of the technologies in Table 4, that would yield additional efficiency savings, though at added cost. The additional technologies include further weight reduction and aerodynamics, and intake valve control, which is on the verge of market introduction. Opportunities for further penetration of technologies listed in Table 4 include multipoint fuel injection (over throttle-body fuel injection), overhead cam engines, and 4-valves-per-cylinder engines. These initiatives would be more expensive than those of Table 4, but would be cost effective if the total lifecycle fuel savings were considered.[35]

Some additional savings might also be necessary to compensate for new safety measures. In particular, we expect a combination of air bags and anti skid brakes to add an average of 70-90 pounds to those vehicles on which they are installed, causing a fuel economy reduction of 1.2-2.0 percent per vehicle.[36]

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[35] The average new car buyer is unlikely to take into account any savings past about 4 years or so unless it is certain that the added fuel efficiency of the vehicle will increase its sales price when he is ready to trade it in...a highly uncertain proposition.

[36] Energy and Environmental Analysis, Inc., contractor report to OTA, op.cit.

D. Basic changes in the composition of the fleet. ***Very large increases in fleet fuel economy can be achieved if consumers are willing to accept lower performance and/or comfort levels.*** Wider use of diesel engines, for example, would offer substantial efficiency gains at the cost of reduced performance. Wider use of 5-speed manual transmissions also would substantially improve fuel efficiency, at lower cost and with improved performance compared to current automatic transmissions. And a shift to smaller vehicles would have a similar effect on fuel economy. For example, there are now a variety of small vehicles, with both gasoline and diesel engines, offering 4 or 5 passenger capacity and achieving fuel efficiencies on the order of 50 mpg or higher.[37] However, these vehicles and technologies have achieved only a very small market share in today's market, and a substantial shift in consumer preferences -- or a strong regulatory mandate -- would be required for them to obtain a large market share.

Shifts in the composition of the fleet could come from changes in consumer preferences associated with increased consciousness of environmental concerns (such as global warming) or renewed concerns about future fuel availability; or, instead, such changes could stem from government regulations. OTA notes at a recent analysis of the costs of creating a shift in the size mix of the fleet (absent market pressures to do so) concludes that such costs would be very high, up to several thousand dollars per vehicle.[38]

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[37] For example, the VW Jetta diesel (5 passengers) at about 47 mpg on-road efficiency, and the GM Sprint (gasoline-powered, 4 passengers) at about 57 mpg.

E. Safety effects of a shift to smaller cars. Safety *will* be an important concern if a substantial push towards improving fleet efficiency involves a significant decrease in vehicle size and weight -- a likely occurrence if fuel economy targets are set very high, considering that many of the "high mileage" vehicles in today's fleet are small and lightweight. Although accident statistics are complicated by several factors (for example, different rates of seat belt usage and different driver age distributions across vehicle size classes[39]), analyses of these statistics show that there is a strong positive relationship between vehicle size and safety[40] -- small cars usually are less safe than large cars. However, differences in crashworthiness among vehicles in the same size class demonstrate that ***careful design can compensate for small size in protecting a vehicle's occupants.***[41] The results of past design competitions sponsored by the Department of Transportation[42] similarly have shown that small cars can be made substantially safer.

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[38] Difiglio, C., Duleep, K.G., and Greene, D.L., Cost Effectiveness of Future Fuel Economy Improvements, submitted to The Energy Journal, January 1989.

[39] In its September 1982 report (op cit), OTA discusses in more detail the complicating factors and ambiguities in accident statistics compiled by the Fatal Accident Reporting System and others.

[40] Ibid. This relationship is particularly strong in statistics on all accidents combined and in car-to-car collisions; it is not certain for single car collisions, although even in this class of accidents, subcompacts fare worse than all other size classes.

[41] Ibid. Also, the results of the crash tests supported by the National Highway Traffic Safety Administration support this conclusion.

[42] e.g., the Research Safety Vehicle Program.

Nevertheless, because small cars are more vulnerable than large cars, all other things equal, strong government incentives towards fuel economy will need to pay careful attention to the safety issue.

There is another side to the safety issue. In an OTA workshop on April 5, 1989, a representative of one of the three U.S. auto manufacturers noted that consumer concerns about safety tended to maintain the share of large cars in the vehicle fleet, because vehicle purchasers perceived -- generally correctly -- that the large cars were safer. Certainly, many purchasers for whom a small, fuel-efficient car would be *functionally* acceptable, and in many ways preferable -- for example, workers seeking a car primarily for commuting, or parents buying a first car for their teenage child -- may instead buy a larger car for safety's sake. Yet the above-mentioned design competitions demonstrated that extremely safe small cars *could* be manufactured. Perhaps such purchasers would be willing to switch away from their full-sized sedans if they were offered an alternative small car with high safety credibility.

F. Selecting a fuel economy target. A 45 mpg new car fleet in the year 2000, even if it proved to be achievable from a technological viewpoint, will not occur without market intervention or early and very substantial changes in oil prices or availability. Whatever its technological risks, the efficiency analysts' year 2000 goal is viewed by the domestic manufacturers as entailing substantial market risks; achieving higher vehicle efficiencies will raise the first costs of new automobiles (and may raise life cycle costs if the costs of introducing the new technologies into the fleet approach the higher end of OTA's previous estimates).

Nevertheless, the large gap between likely, market-driven passenger vehicle fuel efficiencies and technically feasible efficiencies implies a potential for government intervention *if* Congress believes that rising oil imports or other concerns (such as global warming) justify intervention in energy markets. In this case, OTA believes that a fuel economy goal *for the entire new automobile fleet* of about 33 mpg by 1995 should be feasible and cost-effective for the consumer.

* * *

GM

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FE-4266
August 16, 1988

Mr. Steve Plotkin, Project Director
Office of Technology Assessment
600 Pennsylvania Ave., S.E.
4th Floor, Energy & Materials Program
Washington, DC  20510-8025

Dear Mr. Plotkin:

You requested GM's comments on the draft report entitled "Developments in the Fuel Economy of Light-Duty Highway Vehicles." The validity of the report is questionable primarily because it does not clearly separate those technologies that are probable and acceptable to the consumer from those technologies that may be developed but remain commercially unacceptable. If used as intended, i.e., an informational source for Congressional staffs and members, the report could produce in the 1995 time period chaotic CAFE conditions similar to those that exist today for full line domestic manufacturers. Low and relatively stable fuel prices have changed consumers' buying preferences from the conditions that were forecasted in 1975 when the CAFE standards were established. Those standards have not been and are not now in concert with the market. The same could happen in 1995 if this report is used as stated.

We have three major concerns: (1) The report misleads the reader by presenting existing and speculative technology-driven CAFE forecasts that ignore the uncertainty of fuel prices, cost of new technology and consumer demand. (2) It will be difficult for some manufacturers to achieve the fuel economy gains projected over a 1987 base since some have incorporated much of the existing technology into their current products. Setting public policy based on such a forecast could adversely impact domestic manufacturers, their employes, and suppliers while significantly impacting the Nation's economy.

(3) Finally, we disagree with the fundamental economic assumptions and logic underlying the report, starting with the assumption that "economic theory does not suggest that consumers can optimally allocate resources inter-temporally (p. 5-4). The author's economic rationale for any intervention into the market designed to influence fuel economy is a weak one at best under today's energy and auto market conditions, since he fails to document the existence of any significant imperfections in these markets.

The following comments assess specific points raised in each section of the report.

## 1. Introduction

The paper confuses the casual reader with the interchange of "downsizing," "weight reduction" and "size class shift." This paper does not acknowledge weight reduction as a technology in the text (although it does so in several charts). Weight reduction is a technology that GM has successfully utilized to make its largest fuel economy gains while maintaining the same vehicle size class. This technology was very apparent in our 1977-79 A, B, C and E-Body vehicles whose designs were initiated before the first oil embargo.

## 2. Review of Historical Fuel Economy Improvements

This section contains misleading and inaccurate comments about CAFE test procedure adjustments, historical CAFE projections and levels, and the various fuel economy technologies.

Pg. 2-2: The statement in the last sentence that "Some small (0.5 mpg) upward adjustments are made in calculated CAFE values to compensate for some highly technical and minor changes to the test procedure that have occurred since 1975" is a gross error. The Energy Policy and Conservation Act (EPCA) states the test procedures are those utilized by the EPA Administrator for model year 1975, or procedures which yield comparable results. On judicial review, the Court found EPA had made procedural changes that did not yield comparable results and remanded the issue back to EPA, hence, the adjustment which returned the stringency of EPA's test procedures to that which was originally enacted into law by the Congress. The "small 0.5 mpg upward adjustment," if applied to a manufacturer such as GM would offset approximately $88 million in CAFE penalties in a 3.5 million car year. This is not a "minor change."

## 2.2 Aggregate Trends in Fuel Economy

Pg. 2-3: CAFE values quoted in this section are incorrect and do not agree with NHTSA's data. According to a 1988 NHTSA publication, the 1974 domestic fleet CAFE was 13.2 mpg and the import fleet was 22.2 mpg rather than the 12.8 mpg and 21.5 mpg, respectively, as stated in this report. NHTSA's publication also indicates a domestic value for 1987 of 26.7 mpg, not 26.0 mpg.

The last sentence of the first paragraph of 2.2 indicates that "it is popularly perceived that the fuel economy gain was due to downsizing; in reality, technological improvements to cars are the most significant contributors to fuel economy." As we stated earlier, weight reduction or "downsizing," as GM referred to it in 1977 and beyond as it introduced lighter and shorter vehicles while maintaining approximately the same interior room and EPA size class, is a technology that the text of this paper does not appropriately identify for the casual reader.

Pg. 2-5: GM was the driving force behind bringing unleaded gasoline and the catalytic converter technology together and making them available to the public in a given year (1975). This technology allowed the domestic manufacturers to retune their engines (for best fuel economy and power) which had been detuned in the early 1970's to meet emissions standards. It also permitted GM small cars to exceed the fuel economy of Japanese cars of similar weight during this time.

## 2.3 Has CAFE Had Any Effect

Pg. 2-13: The report notes that in model years 1980-82, GM introduced the J-Body and A-Body vehicles which "were fuel efficient and were well received." While these vehicles were indeed fuel efficient, they were not all initially well received and some of these were widely criticized for their reduced acceleration performance. Additionally, GM introduced three other carlines in that time period which did meet those criteria. They were the X-Body (Citation), the K-Body (Cadillac Seville) and the F-Body (Firebird, Camaro). These vehicles were all downsized (in exterior dimensions) while maintaining their same EPA size class, were more fuel efficient than the vehicles they replaced and all except the F-Body incorporated front-wheel drive. In addition, several new fuel efficient engines were introduced in various products.

Rising fuel prices and consumer demand for fuel efficiency through 1982 and not the CAFE standards resulted in the domestic manufacturers exceeding the standards. As fuel prices declined, so did our projected CAFE because of changes in consumer buying preferences. One example of this phenomenon is consumer reaction to our luxury line of mid-size vehicles, (Riviera, Toronado and Eldorado) which were first downsized in 1979. In a climate of rising fuel prices, sales of these more-efficient 1979 MY vehicles rose 135%. In 1985 when these vehicles were downsized for a second time and introduced, fuel prices had declined and were relatively stable. The resulting improvement in fuel economy (3.0 mpg) was not enough to offset the customers' negative perception of these vehicles, since they expected luxury cars to be roomier and more powerful, and sales declined 68%. This points up the uncertainties that exist when product plans, based on future fuel price forecasts 4 to 5 years out, must be finalized.

Pg. 2-14: The report omits any reference to the role forecasted fuel prices played in determining GM's projected CAFE. The 1980 GM statement that our CAFE would exceed the 27.5 mpg was based on a fuel price forecast that projected fuel would be approximately $2.50/gal by 1985. As the actual and future forecasted fuel price declined, product plans had to be modified to meet the future market. An example of how the market changed can be dramatized by the number of plant closings: In 1982, GM closed two newly renovated California plants designed to produce J-Body and A-Body cars after several months of operation because of small and mid-size car overcapacity. In addition, a second Chevette plant in Georgia and an A-Body plant in Massachusetts were closed for the same reasons. In 1984, we had to close the Flint engine plant which had been retooled in 1980 to produce 4-cylinder engines.

GM's noted CAFE for 1985 of 25.4 mpg should be corrected to read 25.8 mpg.

The summary at the bottom of page 2-14 should not attribute CAFE with having a significant effect on fuel economy in 1980-1982, since rising fuel prices increased consumer demand for fuel economy. Further, the reduction of the CAFE standards for MY 1986-88 enabled the domestic full line manufacturers to continue production of larger family-size cars and to avoid massive loss of jobs associated with plant closings that could have resulted had the original fuel economy goal of 27.5 mpg remained as the standard.

Despite the reduction in the standard, larger car producers have been placed at a competitive disadvantage, particularly as the competition from Japan (which is unconstrained by the standard) introduces larger and more powerful cars. Rather than enhancing competition and the choice of more fuel-efficient cars as Congress intended, the CAFE regulation is now reducing competition and choice.

Domestic manufacturers have been improving fuel efficiency while meeting consumer needs for performance and utility. This has resulted in the domestic fleet fuel economy rising from 24.2 mpg in 1981 to an estimated 27.1 mpg in 1988. Increased standards, however, may swing added sales to the unconstrained Japanese products, and cost the U.S. in reduced employment.

## 3. Technology for the 1990s

This entire section could be misleading to the intended audience. It discusses numerous fuel efficient technologies, some of which have been incorporated in today's fleet, but does not consider each technology and its relationship to consumer acceptance -- a very important point manufacturers must consider and one that exerts heavy emphasis on whether any conservation gains will actually be realized. To imply that cost-effective technology exists and is not being introduced ignores the realities of a very competitive market.

3.1 Overview - We agree that prototype vehicles have been demonstrated that can accelerate from 0 to 60 mph in about 15-18 seconds and achieve approximately 90-100 mpg. However, they are not the type of vehicle many consumers want today. While there are models on the market today that exceed 50 mpg (EPA composite), they represent less than 1/2 of 1% of the U.S. market in 1988.

### 3.2 Fuel Economy Technology

Pg. 3-5: With all of the research effort that has been expended on Sterling engines, it is clear that they have little, if any, potential for passenger cars in the foreseeable future. Furthermore, existing and

80's shows that such a theory is clearly lacking, even assuming the existence of the author's purported oligopolies, an assumption which is highly doubtful. Considerable competition between manufacturers characterizes competition in most (if not all) market segments; there is also considerable competition for sales among vehicles in different segments; and, as the draft report mentions, actual and potential competition from Japanese manufacturers and other foreign firms would not long allow domestic manufacturers to offer vehicles with less than desired levels of fuel economy. Thus, there is no evidence that the current vehicle market in incapable to supplying the consumer with cars which offer him his desired level of fuel economy. On the contrary, the work of Crandall, et al. in Regulating the Automobile suggests that the market consistently supplied consumers with cars providing desired levels of fuel economy during the period of rising gasoline prices. The market did so than by introducing those technologies that consumers were willing to pay for. In this regard, the draft report's criticism of the study by Crandall et al. is totally off-base. Nowhere do the authors of Regulating the Automobile maintain that technology was unimportant in achieving increased fuel economy. Rather, those authors would maintain that such technology was introduced only to the extent that it was cost effective in the marketplace.

With respect to the market for crude oil, the case for government intervention is equally weak. The draft report suggests that the price of crude oil may not present the consumer with the full costs of his consumption. This statement was true when CAFE standards were first put into effect, since U.S. crude oil prices were artificially controlled by Federal regulation. Since crude oil prices were decontrolled, this justification no longer exists. Now, the (author's) argument for government intervention rests on the supposed fact that increased crude oil consumption results in external costs not reflected in its market price, that is, additional costs arising from the cost of guaranteeing the Nation's energy security. In this regard, two points should be noted. First, there is little connection between measures to reduce energy consumption and energy security. Measures designed to encourage energy flexibility (e.g., the Strategic Petroleum Reserve, decontrol of oil and gas prices, deregulation and increasing competition in natural gas transmission and distribution, multi-fuel capabilities for industry and electric utilities, research on alternative fuels for transportation, wheeling of electric power, tax and trade policies which encourage or do not discourage diversification of energy and petroleum sourcing both inter-regionally and inter-nationally, etc.) have proven to be and are likely to be far more effective in increasing energy security than are measures whose primary aim is conservation. Second, it is debatable whether some of the measures identified by the report as being undertaken to assure U.S. energy security -- such as the U.S. military presence in the Middle East -- actually serve (or are even primarily intended) to increase significantly our Nation's energy security. The cost of maintaining the Strategic Petroleum Reserve might be viewed by some an an external cost of petroleum use; however, this cost would amount to no more than the equivalent of two cents per gallon for all petroleum consumption.

Thus, this report should have pointed out that given today's market conditions there is little case for intervening in either the petroleum or the auto market to increase fuel efficiency -- and any discussion of "preferred" mechanisms for intervention (whether taxes or standards) should be moot.

Conclusion

Since before the enactment of the fuel economy standards, GM has continued to offer cost beneficial fuel efficiency improvements while remaining a full line manufacturer. We are proud of our achievement of improving our CAFE from 12.0 mpg in 1974 to an estimated 27.6 mpg in 1988. However, CAFE levels outlined in this report could reduce the utility of our vehicles and/or make them too expensive, resulting in the consumers simply retaining their older vehicle, purchase a competitor's product or buy a truck to meet their needs with a loss in energy conservation. If we restrict production to meet the standards, similar results as noted above would be expected. Finally, if we reduce prices to sell our fuel efficient products, other manufacturers must and will take similar action; a stalemate results and our CAFE does not improve.

We believe that reports projecting CAFE based on speculative technology without considering consumer acceptance should not be used as an informational source for Congressional staff and members.

Sincerely,

S. A. Leonard, Director
Automotive Emission Control

mlgs0720

bcc: J. J. Krauss
W. L. Ball ✓
L. I. Dale
R. G. Sykes
C. R. Sharp
J. C. Cubbin
T. L. Arnett
M. L. Kemmer
G. L. Grant
R. G. Frakes
A. W. Kaupert
Log Book
G. F. Stofflet

proposed emission standards may delay or prevent the diesel and 2-cycle engine from gaining commercialization in the timeframe as could cost when considering more than 4 valves per cylinder in a multi-valve engine.

## 4. Potential Fuel Economy in the Future

This section provides fuel economy projections based on additional usage of existing technology and introduction of speculative technology without considering that the benefit gained may not apply equally to each and every carline. In addition, it does not consider if the manufacturer can produce a saleable vehicle in a timely manner or if the consumer will want the resultant vehicle.

4.1 Forecasting Future Fuel Technology - As noted earlier, we strongly disagree with forecasts based solely on hypothetical technology development scenarios which have no expectation of being successfully introduced into commerce. Such forecasts are not useful and could produce significant harm to domestic manufacturers, their employes, suppliers and the Nation's economy if used to set public policy goals. Such an approach was used to establish the 27.5 mpg "target" for 1985 and beyond. Time and conditions have shown that level to be in error.

4.2 Manufacturers Behavior - We question the statement that the U.S. domestic vehicle is expected to assume the shape and size of those in Europe and Japan. To the contrary, public information for 1989 and beyond would indicate the Japanese manufacturers who have excess CAFE credits are moving into competition with the domestic full line manufacturers' large and mid-size cars.

4.4 Technology Cost Effectiveness - The entire report summarized in Figure 4-1 and Tables 4-1 and 4-2 is misleading since it does not (1) forecast the price of fuel for the period of time shown on the chart; (2) give details of any scenarios investigated; (3) consider the manufacturer's ability to commercialize the technology to obtain the gains noted; and (4) consider if consumers will accept the produced product.

Pgs. 4-6 - 4-10: As fuel prices rise, manufacturers have been able to provide increased fuel efficiency which the consumer demands (as they did up through 1982). As fuel prices decline, fuel economy improvements by the domestic fleet continue to be provided where they are perceived, by the consumer, to be cost beneficial and desirable.

We question some of the gains in Tables 4-1 and 4-2. For example, Table 4-1 notes a 3.4% improvement for aerodynamics over today's vehicles which already have made significant aerodynamic gains; Table 4-2 shows another 3.4% gain for a third phase-in of aerodynamics. With the gains already made, we question if the fleet can obtain that type of improvement and the report offers no basis to believe otherwise.

## 4.5 Adverse Effects on Fuel Economy

Pg. 4-17: A statement is made relative to luxury/safety options that "not all cars or even a majority of cars will be equipped with...but it appears that penetrations of 20-30 percent for many of these options are likely by 2000." This is an understatement. Currently, for industry passenger cars, air conditioning penetration is 85%, power seats 30%, power locks 48%, and power windows 45%. Anti-skid braking and air bags are expected to be significant options, probably over 50%, for the domestic industry by 1992.

One major factor that could significantly impact fuel economy and is not mentioned in the report is the current proposed amendments to the Clean Air Act for 1990 which would lower the nationwide NOx standard to 0.4 g/mi, introduce a cold CO standard of 6.2 g/mi (at $20^{o}$F), change the useful life of passenger cars from 5 yr/50,000 miles to 10 yr/100,000 miles and mandate on-board refueling emission control and test fuel volatility requirements. To meet the onboard requirement, additional hardware will be needed resulting in increased weight, and the additional cost could induce consumers to retain older, less fuel efficient vehicles. A related impact of the onboard refueling control requirement is the proposed changes to the Federal test procedure and test fuel properties; both may require adjustments to the CAFE calculations. The exact negative fuel economy impact is unknown at this time, but could be significantly more severe than the anticipated 4-5% impact for the new 1989 California NOx requirement. This requirement will be applicable to 50% of all GM light-duty passenger cars sold in California in 1989 MY and 90% of GM's 1990 MY California vehicles.

## 5. Policies to Influence Future Fuel Economy

We must strongly object to the entire tone and conclusions of this section of the report. This section concludes that while CAFE regulations in their current form unfairly and unwisely discriminate against manufacturers who choose to offer cars in larger, luxury and performance niche markets, some other form of fuel economy regulations might be desirable. While we agree with the first part of this conclusion, we strongly disagree with the second part. The economic rationale for any intervention into the market designed to influence fuel economy is a weak one at best.

As the draft report notes, the only economically justifiable reasons for government intervention designed to increase fuel economy would be external costs not reflected in the price of gasoline, due to significant imperfections in the market for vehicles or in the market for crude oil. The draft report fails to document the existence of any such market imperfections. With respect to the market for vehicles, the report suggests that the existence of oligopolies in various submarkets may cause the market to supply a level of fuel economy less than that desired by the consumer. The increase in fuel economy, clearly surpassing the increase necessary for compliance with the CAFE standard, in the 70's and early

GM

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FE-4273
August 31, 1988

Mr. Steve Plotkin, Project Director
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Washington, D.C. 20510-8025

Dear Mr. Plotkin:

Your letter of August 15 requested that we review the draft material you proposed for Section 4 of the "ANWR oil in the wider context of U.S. liquid fuels supply and demand" entitled, Highway Passenger Vehicles. You particularly requested that the material be reviewed in regards to its technical accuracy and its balance. With regard to balance, this draft appears to be more balanced than the previous report by the OTA contractor, Energy and Environmental Analysis, which we reviewed and commented on in our letter to you of August 16, 1988. However, this material is still weighed heavily towards forced conservation of petroleum and very lightly on the economic consequences of such forcing on the national economy and jobs. Insufficient attention is given these economic concerns, as expressed by such individuals as Robert W. Crandell, Howard K. Gruenspecht, Theodore Keller, Lester B. Lave, Murray Weidenbaum and such organizations as the Brookings Institute, the United States Department of Commerce and the Council of Economic Advisors. (Comments of these, among others, are excerpted in the document, "CAFE, Cars, and Consumer Choice: What Does the Country Really Need?" published by Auto Choice, copy attached.)

The technical accuracy of the draft is compromised by overstating available technology and changing the definition of vehicle fleet.

Three major comments on the draft material are as follows:

- It is misleading to mix car and truck fleets and define that as the passenger vehicle fleet. Passenger cars and light trucks are designed for two different specific purposes and we believe these fleets should be separated when discussing projected fuel economy.
- The U.S. Department of Energy technology chart used in the draft (Table IV-5) is out-of-date and substantially overstates the available technology for fuel economy improvement and significantly understates the cost to the consumer. While OTA indicates they do not

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SAFETY BELTS SAVE LIVES

endorse these reported values, by publishing them OTA further perpetuates their use.

- Contrary to the tenor of this report, auto companies, such as General Motors, must provide their customers with the highest fuel economy possible commensurate with the consumer's demand for utility, aesthetics, image and cost of a new automobile.

While we agree that the U.S. passenger car fleet, excluding trucks, can and will be made more efficient than today's fleet, it will not approach fuel efficiencies double that of today's fleet in this century without severe economic dislocation. The following specific comments relate to the draft material.

On page 2, the first sentence of the second paragraph indicates "without question very large fuel savings can be achieved by increasing fuel efficiency of the U.S. passenger vehicle fleet." While true in the abstract sense, such a claim neglects the practical aspects of whether the consumer will purchase the new vehicle or what happens to fuel consumption if they decide to keep their older vehicles. The second sentence of that paragraph states "the technical capability to achieve substantial fuel savings is available" and later in the paper, the stated mpg goals would indicate "substantial" means more than doubling the current fleet mpg. Such an achievement is totally impracticable considering all the limits stated in the last two sentences of the draft. The remainder of that paragraph is a good discussion of a few specific real world constraints.

Page 3 discusses several factors that tend to raise total fuel consumption. However, it omits other important factors: proposed federal regulations would increase the stringency of the emissions standards, add onboard vapor recovery to all light-duty vehicles and increase useful life from 5/50 to 10/100; and required safety items such as passive restraints and side impact reinforcements. All of these would also increase fuel consumption.

The second bullet on page 3 discusses the role of light trucks in passenger travel and states that light-duty passenger vehicles' fuel economy has increased only 1 mpg since 1981. This should specifically state, using OTA's definition of passenger vehicle fleet, that the combined new car and new light-duty truck fleet fuel economy increased 1.4 mpg from 1981-1987. Additionally, a very important part of this discussion should be that while the domestic car and truck manufacturers have substantially improved the car and truck fleet mpgs between 1981 and 1987, the imported car and truck fleets have both declined in mpg. In addition, truck volume, because of consumer perceived needs, has substantially increased in that time frame. It is these offsetting events, combined with falling fuel prices and economic recognition of the "law of diminishing returns," which have limited the "fleet" fuel economy gains.

The last complete sentence on page 3 should point out that the average

0-60 mpg acceleration time for new vehicles has decreased in every year since 1982 when consumers severely criticized domestic car companies for producing underpowered cars.

On page 4, top paragraph, the parenthetical should be reworded to say (such as lower displacement engines utilizing turbochargers and/or cylinders with 4 valves).

On page 6, second paragraph, it is quite apparent that OTA's projections of 43 mpg to 62 mpg for the new passenger car fleet (trucks excluded) certainly needs to be reviewed and revised. While some improvements can be made, if the entire fleet is to be improved, the Europeans and particularly the Japanese, are going to have to participate as well as the domestic manufacturers. Using EPA's figures as of 8/18/88 and comparing General Motors to Toyota, Nissan and Honda in the period from 1975 to 1988, General Motors has improved its fuel economy 79%, while Toyota has improved 43%, Nissan 18% and Honda a mere 4%. With regards to average weight reduction, General Motors reduced the weight of its average car 27%, while Toyota increased 4%, Nissan increased 12% and Honda increased its average weight 35%.

On page 7, the third sentence of the first paragraph should be revised to read, "However, differences in crashworthiness among vehicles in the same size class demonstrate that careful design can partially compensate...

On page 8, the bottom paragraph discusses the addition of fuel efficient technology and we would agree that the addition of such technology should and will be an evolutionary not revolutionary process. However, as stated earlier, we caution OTA on the use of Table IV-5 which substantially overstates the available technology for fuel economy and understates the cost to consumers. Publishing such a table only perpetuates its further use. In a time of rising fuel prices, the manufacturer can add fuel efficient technology which the consumer will purchase. However, in a period of low or falling fuel prices, improved fuel efficient technology can only be added if it is demonstrably cost effective and/or offers other benefits which the consumer will accept and desire.

The discussion of petroleum consumption projections covered on pages 9-11 indicates that the goals of the energy conservation community are 45 mpg for automobiles and 35 mpg for trucks for MY 2000. Further, they believe these are both technically achievable and cost effective. We strongly disagree with those projections. Fuel economy gains of this magnitude mean a reduction in consumption of 40% from the levels of 1988. This reduction in fuel consumption, based on projected fuel prices, is not possible for domestic auto companies without significant financial dislocation. It is also not technologically possible for domestic manufacturers without further significant downsizing of the car fleet.

On page 9, the conclusions are overly pessimistic regarding the fuel consumption of the in-use passenger car fleet, as defined by OTA (includes cars and trucks), to the year 2000. It is General Motors belief that, even assuming a 15% reduction from the EPA composite value to the in-use value, the overall U.S. in-use passenger car fleet (excluding trucks) will, as a minimum, increase its fuel efficiency 30% between now and the year 2000. This is due to attrition of the fleet and excludes the additional technology gains that may be included in the new car fleet. Using the same assumptions as above, we believe the fuel efficiency of the in-use light truck fleet will improve 42%. This means a fuel consumption reduction of 24% for passenger cars and 29% for light-duty truck in-use fleets between 1988 and 2000. This assumes no change in VMT.

There are several points to be made relative to page 10. They are as follows: (1) the paper should be discussing fuel consumption in either gallons per mile or gallons per 100 miles rather than fuel economy in miles per gallon when projecting how much fuel is going to be saved in the future, (2) it is misleading to compare the passenger car fleet of 1973 with the combined passenger car and light truck fleet of 1987, (3) we disagree with your mpg figures based on data from the Federal Highway Administration (for example, their data show the 1975 in-use average fuel economy for passenger cars is 13.5 mpg and for light trucks 11.2 mpg, and for 1986, their data indicate passenger cars were 18.3 mpg .and light trucks 12.9 mpg), and (4) even the value of 15% reduction from EPA composite to in-use is probably overstated. Studies by General Motors in the early 1980s indicated that the average in-use passenger car achieved the unadjusted city value. Factors that tend to make that percentage even lower are increased use of: front wheel drive vehicles, manual transmissions, fuel injection and diesel engines, all of which tend to achieve on-road in-use fuel economy closer to the EPA composite test value. As we come closer to the year 2000, these factors will cause that percentage to decrease.

While the OTA must cautiously review projections made by the auto industry of expected future capabilities in reducing fuel consumption, they must do the same when looking at projections by the energy conservation community or government contractors as to the benefit they may receive from any final regulation or investigations.

Finally, as we stated in our earlier response, reports suggesting unreasonably high fuel economy improvements could produce in the year 2000 time period, chaotic CAFE conditions similar to those that exist today for full-line manufacturers. Low and relatively stable fuel prices have changed consumers' buying preferences from the conditions that were forecasted in 1975 when the CAFE standards were established. Those standards have not been and are not now in concert with the market. The same could happen in the year 2000.

If you have any questions, please call me or Gerald F. Stofflet of my staff on (313) 947-1881.

Very truly yours,

Samuel A. Leonard

Samuel A. Leonard, Director
Automotive Emission Control

att.
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Warren, Michigan 48090-9015

FE-4316
November 30, 1988

Mr. Steve Plotkin, Project Director
Office of Technology Assessment
Energy and Materials Program
600 Pennsylvania Avenue, S.E., 4th Floor
Washington, D.C. 20510-8025

Dear Mr. Plotkin:

This is in response to your letter requesting information on prototype vehicles and a comparison of technology used in various GM engines.

## Prototype Vehicles

In 1982, GM completed the construction of a one-of-a-kind prototype vehicle called the TPC (Two Passenger Car). This small, but spacious experimental vehicle, which could satisfy the basic transportation needs of two occupants, was designed and built to measure the practical limit of fuel economy against other worldwide designs. Since the objective of the TPC project was to achieve the maximum fuel economy with the best known technology and assess its efficiency against the other worldwide designs, the U.S. government emissions and safety requirements were excluded from this vehicle.

The TPC was 33 inches shorter, 5 inches narrower and 6.6 inches lower than the 4 passenger Chevrolet Chevette, which was GM's smallest and lightest U.S. vehicle at that time. At 1040 lbs., the TPC weighed only one-half as much as the Chevette.

The fuel economy achieved by the front-wheel drive TPC was 68 mpg - city, 95 mpg - highway and 78 mpg - composite when tested on the EPA test schedule. On the road at a constant 40 mph, it measured 102 mpg.

The TPC was powered by an experimental three-cylinder, 4-stroke, 800 cc all-aluminum gasoline engine through a manual five-speed transmission. The engine incorporated electronic port fuel injection with fuel shut-off during coast, ram-tuned manifolds, swirl intake ports, fast burn combustion chambers, 9.5:1 compression ratio and electronic direct-fire ignition with knock limiter. All of the moving components were designed to minimize friction losses for maximum efficiency. The engine's output was 38 HP at 5200 rpm and 48 lb.-ft. of torque at 2400 rpm.

Let's Get It Together
SAFETY BELTS SAVE LIVES

The integral steel body of the TPC weighed only 244 lbs. and its structural design was dominated by a backbone tunnel. This design resulted in acceptable beaming and torsional resonant frequencies. The hood, front fenders, doors and several underhood components were made of aluminum.

Aerodynamic features used on this vehicle included a smooth front end, a flush front-end panel with an integral air dam, flush-mounted glass, flush wheels and tires, a smooth underbody, a roof extension over the hatch and no external protuberances, such as side view mirrors.

The front and rear suspension designs relied on the use of components constructed of fiberglass-reinforced epoxy resin.

To reduce weight further, some components, such as the door glass roll-down mechanism, were eliminated.

To reiterate, this prototype vehicle was a one-of-a-kind vehicle to determine the practical limit of fuel economy, without the constraints of all the U.S. governmental regulations concerning emissions and safety. If this vehicle were redesigned to conform with all regulations, its aerodynamic drag, rolling resistance, and weight would be increased -- all at considerable reduction in the achieved fuel economy.

By comparison, GM currently offers for sale to the public, a 1989 GEO Metro with a 1-liter three-cylinder engine and five-speed manual transmission that achieves 59 mpg - city, 75 mpg - highway and 65 mpg - composite on the EPA test procedure -- the highest fuel economy of any production automobile sold in the U.S.

On the subject of prototypes, I am enclosing an information sheet on GM's 1988 Sunraycer. This vehicle traveled 2000 miles across Australia at an average speed of 43 mph without using any petroleum whatsoever -- you might say, infinite mpg.

## Technology Issue

QUAD-4 (2.3) vs. 6-CYLINDER ENGINES (Push-Rod) - As GM has previously stated, the fuel economy gains of the Quad-4 engine on the EPA test procedure are due to technology improvements and not the fact that it has 4-valves per cylinder. In fact, the 4 valve mechanism (DOHC) increases friction over a similar 2-valve per cylinder (SOHC) configuration. The Quad-4, when tested in the engine rpm range encountered on the EPA test, develops maximum output torque and horsepower that are lower than either the 2.8L or 3.0L V-6 (push-rod design) engines. However, as engine speed reaches the high end of the range, the Quad-4 (DOHC) demonstrates higher torque and horsepower than either the SOHC or push-rod engines.

While it is true that the GM Quad-4 achieves better fuel economy than the 2.8 V-6 engine at equivalent 0-60 mph acceleration capability, it is also true that the Chevrolet Beretta equipped with the 2.8L V-6 achieves better fuel economy and better acceleration than the Toyota Camry 2.5L - V-6, (4 valve/cylinder) and at a lower price. Therefore, the Beretta/Corsica with today's 2.8L V-6 push-rod engine represents a better value to the consumer.

QUAD-4 (2.3L) vs. 3.0L V-6 - The comparison of the 2.3L and 3.0L "N" cars given in the OTA contractor's letter of August 25, 1988 is a comparison of engines which are far apart technically. Differences in fuel economy arise from three primary sources.

The first source is friction. The Quad-4 represents the most modern design technology utilizing low-friction components. The 3.0L was a higher friction engine which did not utilize what we now know as the latest in piston and ring designs and, in addition, did not have the centerline of each rod bearing in line with the center of the corresponding cylinder bore. The 3.0L design was a necessary step in the evolutionary development of the 90 degree V-6 engine to improve its vibration characteristics and, therefore, make the V-6 more acceptable to consumers who were accustomed to smooth operating V-8 engines. The total of the friction differences is such that at 2000 rpm part load, the friction of the 3.0L is over 50% more than that of the Quad-4.

The second factor affecting fuel economy is throttling losses. Larger displacement engines are generally more highly throttled at a given road load condition.

The third factor is the indicated thermal efficiency, which is the result of combustion and thermodynamics. The 2.3L has a bore/stroke ratio of 1.08 and a compact combustion chamber with a central spark-plug location. The 3.0L had a large bore/stroke ratio of 1.43 and a less favorable combustion chamber. These differences contribute to higher heat losses with the 3.0L, and when combined with its lower compression ratio, give the 3.0L a lower indicated efficiency.

## Computer Simulation

Using a sophisticated engine simulation program, the 3.0L V-6 was systematically modified to a low-friction 2.3L push-rod V-6 engine. After establishing comparable simulation baselines of 26.87 mpg for the 2.3L engine and 21.63 mpg for the 3.0L engine on the EPA Urban test in the same vehicle, the friction data in the 3.0L engine map were replaced with the scaled (for displacement) friction from the Quad-4 (2.3L) at the same speed and manifold pressure. The difference in friction was added to brake torque, maintaining indicated torque and efficiency. With this simulated low-friction 3.0L engine, the fuel economy increased from 21.63 mpg to 22.84 mpg, or 5.6%, on the EPA Urban test.

In the next simulation, the low-friction 3.0L engine was downsized to a 2.3L engine, resulting in the Urban fuel economy being increased to 25.86 mpg, which is 19.6% above the base vehicle and 3.8% below the Quad-4 (2.3L) vehicle. By adjusting the compression ratio of the low-friction, downsized 3.0L engine from 9.0 to 9.5, the ratio of the Quad-4 (2.3L), the simulated Urban fuel economy became 26.55 mpg, or 1.2% below the base Quad-4 (2.3L) vehicle. Most of this small difference is attributed to the higher heat losses inherent with the large bore/stroke ratio of the 3.0L engine. Some is due to the slower burning of its combustion chamber.

This simulation systematically explains the differences in the Quad-4 (2.3L) and 3.0L vehicle fuel economies. It also supports the well documented fact that fuel economy is greatly impacted by engine displacement, followed to a much lesser degree by thermodynamic and frictional differences.

Within the range of vehicle performance acceptable to the consumer, a given displacement engine could be a push-rod, SOHC and DOHC design. The part-load performance would be about the same for all configurations. Only at the higher engine speeds would the OHC arrangements excel in performance. If, however, the higher engine speed performance level of a push-rod engine was not deemed sufficient and the push-rod design was required, either a larger displacement or a charge-air system would be necessary. Both would result in a fuel economy penalty.

## Dynamometer Test Results

On dynamometer tests conducted at GM Research Labs, the Somerset with a 3.0L achieved a combined fuel economy of 27.3 mpg, and the 2.3L Calais achieved a combined economy of 30.5 mpg. The fuel economy numbers differ from the EPA test data because of tire differences and test variability. In this case, the difference between vehicles is only 11.7%. Looking at a graph of steady-state fuel economy (Figure 1), we see that fuel economy differences are most pronounced at level road load, where friction and throttling are more significant. In tests to simulate a 3.5% grade (a moderate grade equal to one-half the maximum allowable on interstate highways), the engine is more heavily loaded, the effects of throttling and friction are proportionally less significant and the fuel economy of the two engines become similar.

None of these data nor the simulation suggest that there is an inherent efficiency advantage to a four-valve engine. Moreover, the use of such an engine involves trade-offs which may not appeal to some customers.

## 3.0L V-6 Engine Replaced by 3300 V-6 Engine in 1989

In MY 1989, continuing the evolution of the 90 degree V-6 engine, the 3.0L V-6 has been replaced with the new 3300 (3.3L V-6) engine with on-center bores and much improved friction and a more favorable bore/stroke ratio which improves the combustion process. This engine has improved the composite fuel economy of the "N" car from 25.9 mpg with the 3.0L to 27.6 mpg with the 3300. Performance and driveability have improved concurrently. Comparison of the 2.3L DOHC with the 3300 2-valve push-rod engines is given below:

| Car | Engine | Trans. | City/Highway/Composite | 0-60 MPH |
|---|---|---|---|---|
| "N" | 2.3L DOHC | A3 | 25.5/41.2/30.8 | 9.7 |
| "N" | 3300 OHV | A3 | 23.1/36.3/27.6 | 9.5 |
| | MPG Change | | 2.4/4.9/3.2 | 0.2 |
| | Percent Change (V6 Base) | | 10%/13%/12% | -2% (2.3L slower) |

Conclusion: At equivalent levels of performance, the Quad-4 has a 10-13% advantage in fuel economy, due primarily to the difference in displacement.

QUAD-4 (2.3L) vs. 2.8L V-6 - GM has not individually tested each technology in these particular engines to determine an exact fuel consumption difference; however, from our history of experience with each technology on a variety of engines, we can establish a range of consumption that will apply.

2.8L OHV Engine/Manual 5-Speed Transmission:

Tested composite fuel economy = 26.3 mpg
or, in consumption 3.8023 gal/100 miles.

The fuel consumption can be adjusted for the technology difference between the 2.8L V-6 and the Quad-4 (2.3L) DOHC engine as follows:

| | Fuel Consumption Range (gal/100 mi) | |
|---|---|---|
| Baseline 2.8L V-6 Consumption | 3.8023 | 3.8023 |
| Decreased Displacement (Pumping Loss) | -.300 | -.375 |
| Increased Compression Ratio | -.023 | -.068 |
| 4 vs. 6 Cylinder (Friction) | -.038 | -.038 |
| OHC vs. Push Rods (Friction) | -.038 | -.076 |
| Lower Bearing Area (Friction) | -.015 | -.038 |
| Combustion Chamber Design | -.038 | -.076 |
| Chassis Variation | -.038 | -.076 |
| Higher Dyno Set HP | +.029 | +.029 |
| Adjusted Consumption Range | 3.3413 to | 3.0843 gal/100 mi. |
| or | 29.9 | to 32.4 miles/gal. |

The 1988 EPA composite fuel economy of the Grand Am with the Quad-4 DOHC engine, noted in your letter, is 32.2 mpg, which falls within this range.

## Market Considerations

General Motors introduced the Beretta, utilizing two different engines to meet the market requirements. The base engine is the 2.0 liter 90 horsepower OHV (two valve push-rod) 4 cylinder. This engine provides adequate power, low purchase price, and high economy (achieved 32.4 mpg composite on the EPA test schedule). The optional engine is the 2.8 liter 130 horsepower OHV (two valve push-rod) 6 cylinder which provides more power for increased loads, good economy, and smoother, quieter operation. Customer feedback to General Motors assures that these products are successfully meeting their respective owners' expectations. As a point of interest, if fuel economy was the only consideration, it would be maximized for the Beretta by simply offering only the 2.0-liter 4 cylinder. However, this approach would risk severely reduced sales volume (and therefore jobs) in the market considering that 60% of the 1988 Corsica/Beretta carline was purchased with 6 cylinder engines.

Further, GM does not agree with the implication that the higher technology of the 2.3 liter 150 horsepower DOHC 4 cylinder engine could fill the same market requirements as the 2.8 liter V6 while providing better economy. First, our experience has shown that many of our customers make purchase decisions based upon their previous experiences and their perceptions. As a consequence, many prefer V8 engines over V6 engines and many more prefer V6 engines over L4 engines. This situation is no different from that where many customers would not purchase a diesel engine regardless of the higher economy or would not purchase a more complex turbo-charged engine, regardless of power. Second, the operation and driveability of these engines are not the same, as a result of differences in their basic design characteristics. Even though the 0-60 mph acceleration times of each of the vehicles powered by one of these engines is close, the result was accomplished by taking two very different design directions keyed to the intended customer.

Figure 2 plots the horsepower and torque values for both the 2.8L V6 and the Quad-4 (2.3L) DOHC engine. From the graph, it is readily apparent that the DOHC engine develops its high horsepower above 4500 rpm. Engineers are able to take advantage of its multiple valves (increased volumetric efficiency) and more efficient and lighter weight valvetrain (less inertia and friction) to provide better performance potential at the extended rpm range. The difference in the torque curves results in a character difference between the two engines with each having its own strengths and weaknesses.

Zero to 60 mph time is only one measure of a vehicles acceleration performance capability; consumers use a wide variety of subjective criteria -- "off the line," passing, freeway merging, and moderate acceleration "feel," etc., to evaluate "performance." Different engine designs perform differently, and each has a segment of the market to which it appeals.

Manufacturers compete to produce vehicles which must satisfy unique customer requirements and expectations. In a market where the mere difference in accelerator pedal return spring tension can give the perception that a vehicle is a good or better performer, there are far more considerations than simply fuel economy and 0-60 mph acceleration to produce a commercially viable automobile. Our customers judge our products in light of many other elements, such as their perception of product quality, cost, style, driveability and durability, just to mention a few.

If you have any questions, please call me or Gerald F. Stofflet of my staff on (313) 947-1881.

Sincerely,

S A Leonard

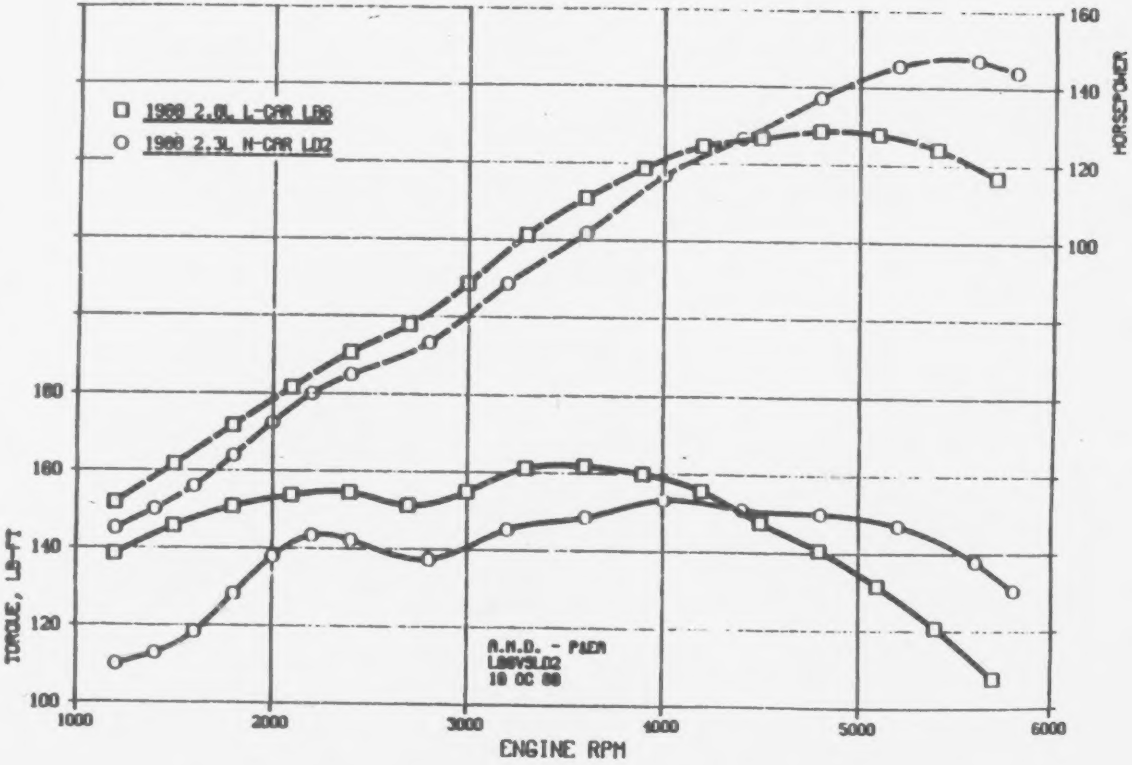
S. A. Leonard, Director
Automotive Emission Control

mlrf1116

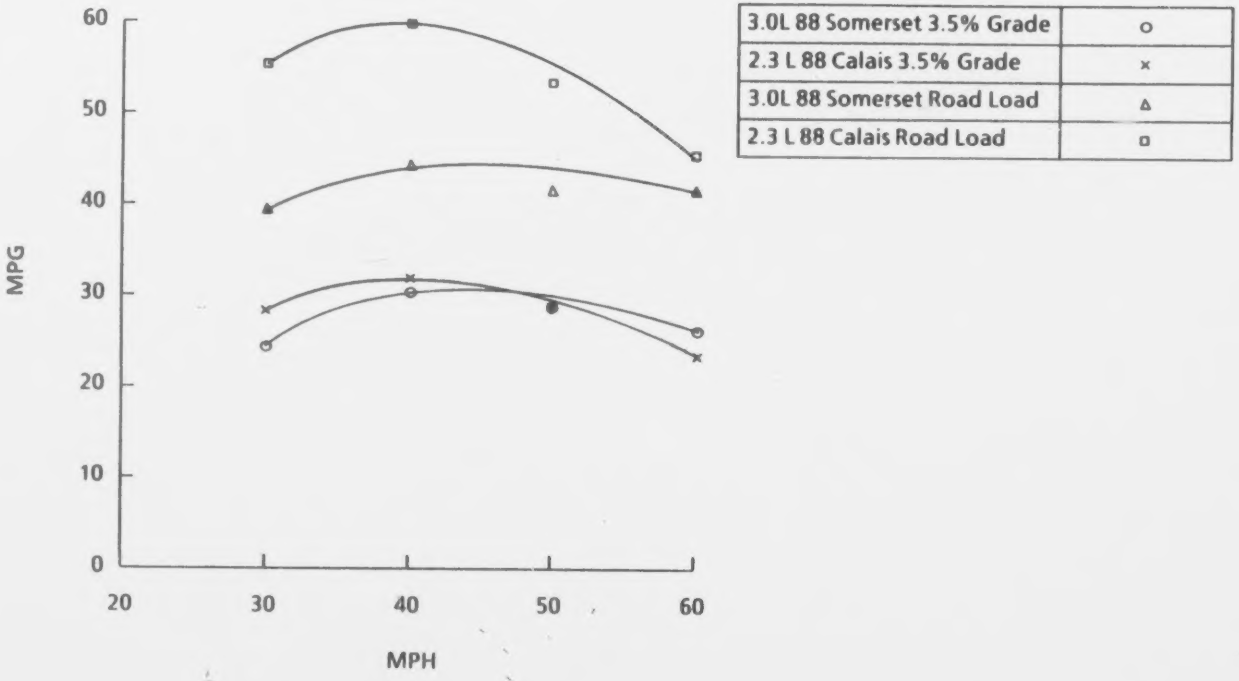
bcc: T. Lakin, CPC
O. Padilla, BOC Powertrain
R. Wiltze, CPC
D. Frincke, BOC Lansing
D. Lancaster, GMR
C. Amann, GMR
W. Haverdink, GMR
R. Miller, BOC Flint
T. Arnett, Legal Staff
R. Lundquist, BOC Powertrain
M. Vander, CPC Powertrain
W. Gornick, CPC Powertrain
G. Mullan, K&E
J. Krauss
W. Ball
L. Dale
R. Sykes
C. Sharp
T. Arnett
J. Cubbin
G. Stofflet
R. Frakes
A. Kaupert
Log Book

FIGURE II

POWER COMPARISON



## MPG VS. MPH
## AT
## ROAD LOAD AND 3.5% GRADE
## FIGURE I



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WORKING
PAPERS

# THE IMPACT OF AUTOMOBILE FUEL ECONOMY STANDARDS

Andrew N. Kleit

WORKING PAPER No. 160

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BUREAU OF ECONOMICS
FEDERAL TRADE COMMISSION
WASHINGTON, D.C.

# The Impact of Automobile Fuel Economy Standards

Andrew N. Kleit

Federal Trade Commission

The views presented here are solely those of the author and not those of the Federal Trade Commission or any of its members. The author would like to thank Alvin Klevorick, Richard Levin, Merton Peck, and Robert Rogers for their help with this paper.

## I. INTRODUCTION

Since 1978 the Federal government has mandated that new fleets of all firms selling over 10,000 cars per year in the United States reach a certain level of average fuel efficiency. CAFE (Corporate Average Fuel Economy) standards were intended to decrease energy consumption by automobiles. In 1985, under an escape clause in the CAFE legislation, General Motors and Ford petitioned the National Highway Transport and Safety Administration (NHTSA) for relief from the standards. GM and Ford claimed that meeting the standards for model year 1986 would cause significant economic damage, and requested that the 1986 model standard be lowered from 27.5 to 26.0 MPG. GM and Ford repeated this process in 1986 for model year 1987. Opponents of the petition claimed that granting the petition would generate a substantial increase in energy consumption with little or no gain to the economy. The auto manufacturers' requests were granted in both 1985 and 1986, but not before sparking heated public debate.

Stucker et. al [1980] have examined the equilibrium impact of CAFE standards on the market for automobiles and energy. They did not, however, investigate the effects of a one year change in the standard, such as the question facing NHTSA in various years. Kwoka [1983] derives a model of how a monopoly firm could be expected to react to the imposition of a CAFE standard.

Section II of this paper will present a brief outline of the CAFE program and debate. Section III extends the analysis of Kwoka to a competitive framework and demonstrates how CAFE standards can have several perverse impacts. In particular, it is shown that CAFE standards discourage specialization among automobile firms and indeed, creates a special regulatory economies of scope. These, however, are not real economic efficiencies.

The magnitude of these effects is then presented in Section IV with a simulation of market performance. The simulations demonstrate who gains and who loses from the imposition of various CAFE standards. The results of the simulation in the automobile market are then used to estimate the savings in gasoline consumption from the imposition of CAFE standards. It is shown that CAFE standards are an extraordinarily expensive method of saving energy. The nature of the CAFE regulation, however, make it possible for certain automobile firms to increase their profits through the imposition of higher standards. The conclusion of this paper is that CAFE standard may or may not generate reductions in gasoline consumption. If they do, it is only at a very large cost to the economy. While the economy as a whole appears to be adversely affected, this analysis shows that firms that are in the proper position in the marketplace may find the imposition of CAFE standards to be highly profitable.

## II. DESCRIPTION OF CAFE REGULATIONS

The CAFE program, as enacted in 1975, called for all manufacturers selling more than 10,000 auto units per year in the United States to reach the mandated CAFE levels. CAFE levels were to rise from 18.0 MPG in 1978 to 27.5 MPG in 1985 and later years. The measurement of a firm's CAFE level was not defined as the simple average of a manufacturer's fleet MPG. Instead, firm's CAFE level is the harmonic average of that firm's fleet

MPG[1] (discussed below). One property of a harmonic average is that if it is, doubled, fuel consumed by driving the same number of miles in each type of car is halved.

If a review process finds that a manufacturer has not met the CAFE standard, that manufacturer is subject to a civil fine. The level of the fine is set equal to fifty dollars times the difference in MPG between the CAFE standard and the fuel economy actually reached by the firm times the number of automobiles produced by the firm in that year. For example, if the standard is 20 MPG, and a producer makes one million cars with a harmonic average fuel efficiency of 18.5 MPG, that firm is liable for a fine of $75 million. Firms, however, are reluctant to be seen as lawbreakers; they therefore appear to view the standards as binding.[2] Apparently, the implicit cost of breaking the law is greater than the additional cost of reaching the CAFE standard.

Under the statute a firm can apply credits earned during the three previous model years to its CAFE level in a given year. If no such credits are available, the firm has the option of using credits it expects to earn in the next three model year, if it can convince NHTSA that such an expectation was reasonable. This carry forward/back provision of the CAFE program was designed to increase firms' flexibility. The legislation divided a firm's fleet into two distinct groups. All domestic cars and all foreign cars of a firm were to be averaged separately.[3] This provision was designed explicitly to prevent U.S. manufacturers from meeting the CAFE standard by importing small foreign cars.[4]

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[1] Public Law 46:15-2003.

[2] General Motors and Ford have stated on numerous occasion in 1985 and 1986 before Congress and in submissions to NHTSA that they viewed the standards as binding and would not contemplate paying fines. The only firm that has actually paid CAFE fines is Jaguar. However, when Jaguar was spun off from British Leyland it was explicitly stated in Jaguar's articles of incorporation that Jaguar expected to pay CAFE fines. This apparently reduced the legal cost to Jaguar of paying the fines.

NHTSA was given the authority to modify the standard for model years after 1984, to the "maximum feasible average fuel economy" after taking into account four factors: technological feasibility; economic practicability; the effect of other federal motor vehicle standards such as emissions controls on fuel economy; and the need of the nation to conserve energy. NHTSA was given clear authority to modify the post-1984 standards between 26.0 and 27.5 MPG. Any modification outside this range was subject to a one house veto by Congress. Such legislative vetoes were later declared unconstitutional by the Supreme Court.

## III. THEORETICAL ANALYSIS OF CAFE STANDARDS

There was only a period of a few months between the time the CAFE relief was filed by GM and Ford and the beginning of the model year to which the CAFE standard was to apply. Indeed, in both model years 1986 and 1987 NHTSA did not announce that it was granting relief until the very start of the model year. In the short time available, the Big Two would not have been able to increase the fuel efficiencies of particular automobiles, for such technological changes generally take several years to put into place. GM and Ford had already exhausted their supply of credits earned in previous years. Thus, if NHTSA had denied the relief petition, the only course of action available to these two firms would have been to "mix-shift," that is to sell more fuel efficient cars and fewer fuel inefficient cars to meet a CAFE standard of 27.5 MPG. The next part of this section will extend Kwoka's analysis of a monopoly firm to a competitive market to show the reaction to a regulation that requires a short run adjustment to mileage standards through mix-shifting.

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[3] Under a provision in the 1980 amendments to the CAFE law, Volkswagen's domestic production is included with its foreign output when determining VW's CAFE level.

[4] NHTSA annual report on fuel economy, 1982, at 9.

## Reaction of a Firm to a Binding CAFE Standard

Consider a competitive firm that makes both large and small cars. Let $Q_1$ and $q_1$ stand for the quantities of large and small cars built by the firm. $M_L$ and $M_s$ stand for the fuel efficiency of each type of car in miles per gallon. Large cars sell for price P and small cars for price p. Assume that a firm has the following cost functions, which imply a linear, upward sloping marginal cost curve:

$$(3\text{-}1)\quad C(Q_1) = aQ_1 + .5bQ_1^2 \quad a,b>0$$

$$(3\text{-}2)\quad C(q_1) = eq_1 + .5fq_1^2 \quad e,f>0$$

The firm faces a CAFE standard S, $M_s>S>M_L$. This requires with harmonic averaging that

$$(3\text{-}3)\quad S \leq (Q_1+q_1)/((Q_1/M_L)+(q_1/M_s))$$

or

$$(3\text{-}4)\quad q_1 \geq RQ_1$$

where $R = ((S/M_L)-1)/(1-(S/M_S))$. Note that as S approaches $M_L$, R approaches 0. As S approaches $M_S$, R approaches infinity. The firm thus has the objective function

$$(3\text{-}5)\quad \text{Max } \Pi = Q_1(P-a-.5bQ_1) + q_1(p-e-.5fq_1)$$
$$\text{s.t. } q_1 \geq RQ_1$$

Assume the constraint is binding, and let T be the shadow cost of the constraint. Taking derivatives gives:

$$(3\text{-}6)\quad d\Pi/dQ_1 = P-a-bQ_1-RT=0$$
$$(3\text{-}7)\quad d\Pi/dq_1 = p-e-fq_1+T=0$$
$$(3\text{-}8)\quad d\Pi/dT = q_1-RQ_1 = 0$$

Solving (3-6) and (3-7) yields

$$(3\text{-}9)\quad P = MC(Q_1) + RT$$

$$(3\text{-}10)\quad p = MC(q_1) - T$$

where MC( ) stands for marginal cost. (3-9) and (3-10) demonstrate that when the constraint is binding CAFE standards act as a shadow tax on large cars and a subsidy on small cars, discouraging the production of the first and encouraging the production of the second. The only difference between the implicit taxes and subsidies generated by the standard and an explicit tax/subsidy scheme is that under the CAFE standard the producers get to keep the tax revenue. This tax revenue, however, must be used to subsidize the production of small cars.

Even though the regulation is a constraint on the firm, it can actually increase firm output, measured as $q_1+Q_1$. Solving the above equations for quantities $Q_1$ and $q_1$ yields

$$(3\text{-}11)\quad Q_1+q_1 = (P-a)/b + (p-e)/f + T(1/f-R/b)$$

where the shadow tax has the value

$$(3\text{-}12)\quad T = ((e-p)b+(P-a)fR)/(b+fR^2)$$

If CAFE standards are binding T is positive. Therefore output rises if

$$(3\text{-}13)\quad R < b/f$$

This points to an interesting feature of CAFE regulation. If the standard is binding, but at a low enough level, CAFE standards may actually increase firm output, and perhaps even employment (See Henderson [1985]). Output is more likely to rise the smaller f is (the flatter the slope of the marginal cost curve for small cars), as this implies that the CAFE subsidy on small cars will have a larger quantity impact. This can lead to the perverse effect Kwoka discussed, where a CAFE standard leads to an increase in the number of cars on the road, and therefore to an increase in total gasoline consumption.

Note that as R approaches infinity (S goes to $M_s$), RT (the implicit tax on large cars) approaches (P-a) and no large cars are produced. The implicit subsidy on small cars, T, goes to zero as R goes to infinity. Thus, an extreme CAFE standard may not directly subsidize the production of small cars. An intuitive explanation of this is as follows: CAFE regulation implies a zero net subsidy to the firm. If the firm does not produce any large cars, it does not generate any tax revenue to use for subsidizing its small car production.

This simple model illustrates two important aspects of the CAFE program. First, the standards can act as an implicit tax on large cars and an implicit subsidy on small cars. Second, the industry output and employment effects of the CAFE program may be positive. These points are very important to the analysis of this regulation.

### Reaction of Industry To Binding CAFE Standards

The model can be extended to cover all firms in a competitive sector. It will be shown that under a binding CAFE standard industry output and perhaps even industry profits can rise. Let RT equal the tax on large cars and T equal the subsidy on small cars. T is determined endogenously as a function of R. Assume that there are N firms in the industry with cost functions identical to those of the firm described above. Let $Q^T$ and $q^T$ equal the industry output of large and small cars. ($Q^T = \Sigma Q_i$, $q^T = \Sigma q_i$, i representing an individual firm in the industry.) Industry supply functions are generated by horizontally adding each firm's marginal cost curve

$$(3\text{-}14)\ P(Q^T) = MC(Q^T) = a+(bQ_i/N) + RT = a+BQ_T + RT$$

$$(3\text{-}15)\ p(q^T) = MC(q^T) = e+(fq_i/N) - T = e+Fq^T - T$$

Industry demand curves are

$$(3\text{-}16)\ P(Q^T) = g-hQ^T$$

$$(3\text{-}17)\ p(q^T) = j-kq^T$$

(Cross-price effects are omitted for the sake of simplicity. This omission does not significantly alter the results of this section.) Solving for firm output and implicit subsidy levels, we have

$$(3\text{-}18)\ T = T(R) = (R(g-a)(k+F)-(j-e)(h+B))/(h+B+R^2(k+F)),$$

$$(3\text{-}19)\ Q^T = (g-a-TR)/(h+B) \qquad P = g - h(g-a-TR)/(h+B),$$

$$(3\text{-}20)\ q^T = (j-e+T)/(k+F) \qquad p = j - k(j-e+T)/(k+F).$$

Total industry output $Q^T + q^T$ is

$$(3\text{-}21)\ Q^T+q^T = (g-a)/(h+B) + (j-e)/(k+F) + T((1/(k+F))-R/(h+B)))$$

Similar to the results for one firm shown in (3-13), industry output will rise as a result of the shadow tax (given R constant) if and only if

$$(3\text{-}22)\ R < (h+B)/(k+F)$$

In a competitive industry CAFE standards may thus have the effect of raising firm output and perhaps employment. The reasoning is the same as in the single firm case. The steeper or less elastic the demand and supply curves for large cars (h and B) the less effect a CAFE tax will have on reducing large car output. The flatter or more elastic the demand and supply curves for small cars (k and F), the more a CAFE tax will increase the output of small cars.

Industry profits in the model presented equal

$$\begin{aligned}(3\text{-}26)\ \Pi = {} & (g-a-TR)^2/(h+B) + ((g-a-TR)/(h+B))^2(-h-.5B) \\ & + (j-e+T)^2/(k+F) + ((j-e+T)/(k+F))^2(-k-.5F)\end{aligned}$$

It may be that firms would actually desire a higher CAFE standard to be imposed on them. Looking at the derivative of profits with respect to a change in the standard R

$$\begin{aligned}(3\text{-}27)\ d\Pi/dR = {} & -2(T+RdT/dR)(g-a-TR)/(h+B) \\ & +(2h+B)(T+RdT/dR)(g-a-TR)/(h+B)^2 \\ & +2(dT/dR)(j-e+T)/(k+F) \\ & -(dT/dR)(2k+F)(j-e+T)/(k+F)^2\end{aligned}$$

where

$$(3\text{-}28)\ dT/dR = (k+f)(g-a-2RT)/(h+B+R^2(k+F))$$

CAFE standards would increase profits if $d\Pi/dR > 0$, or (substituting in (3-19) and (3-20) in (3-27)),

$$(3\text{-}29)\quad Q^T(T+RdT/dR)(((2h+B)/(h+B))-2) + q^T(dT/dR)(2-(2k+F)/(k+F)) > 0$$

For instance (assuming $dT/dR > 0$, which is true at $T=0$), the regulation would be more likely to increase profits the lower f (the smaller the increase in marginal costs for small cars). Or the higher h (the lower the elasticity of demand for large cars), the more likely that CAFE standards will increase profits. Similar results can be derived for an oligopolistic industry (see Kleit [1987]), but not for the monopoly firm Kwoka described, since a monopoly is already maximizing profits. Intuitively, the standards act to impose a cartel-like restriction on the output of large cars whose profits can outweigh the losses in the small car sector. This may explain why in the early years of the CAFE program GM and Ford were supporters of strict CAFE standards (See Yandle [1980]).

## The Mathematical Form of the CAFE Tax

Recall from section II that the explicit fine on a firm is equal to

$$(3\text{-}30)\qquad F = 50*(Q_1+q_1)*(S-MPG)\qquad MPG<S$$

of the firm does not reach the standard, where S is the level of the CAFE standard, $Q_1$ and $q_1$ are the number of large and small cars sold by the firm, and MPG is the firm's harmonic average fuel efficiency. The harmonic average for the firm is calculated by

$$(3\text{-}31) \qquad MPG = (Q_1+q_1)/((Q_1/M_L)+(Q_1/M_s))$$

where $M_L$ and $M_s$ are the fuel efficiencies of the two types of cars. Harmonic averaging has the following property: If the number of miles driven stays constant and fuel economy is doubled, fuel usage is cut in half.

Using the harmonic average, the marginal CAFE fine to the firm of producing a car of type 1 is

$$(3\text{-}32) \qquad dF/dQ_1 = 50*(S-2MPG+(MPG^2/M_L))$$

Assume now that the standards are binding. In that case MPG=S, the explicit fine of $50 per MPG is replaced by a shadow tax L and the implicit CAFE tax on a car of type 1 becomes

$$(3\text{-}33) \qquad dF/dq_1 = L*S*((S/M_L)-1)$$

where L is the value of the constraint discussed above.

The marginal fine derived above presents a more difficult problem to manufacturers than would occur with a standard based on simple averaging. Consider a firm that is deciding whether or not to produce an additional car with fuel efficiency equal to 20.0 MPG where the binding CAFE standard is 27.5 MPG. If simple averaging were used, the firm would have to offset that additional unit by producing one car with fuel efficiency of 35.0 MPG (or the equivalent). Under harmonic averaging, however, to produce another unit of 20.0 MPG, the firm must also produce the equivalent of one unit with fuel efficiency of 44.0 MPG. Thus, compared to simple averaging, the harmonic averaging used makes the CAFE standard more difficult to meet.

## The Effects of CAFE Standards on Industry Structure

It would appear that firms feel themselves legally unable to pay CAFE fines and thus must meet the standard. Consequently, if a firm specializes in low mileage cars, it may seek to merge with a high mileage firm in order to meet the standard.

Merger is not the only way in which firms can react to the standard. It may be that for a variety of reasons a suitable merger partner is not available to a firm. In that case, a firm below the standard may resort to building its own high mileage cars, even though it has a comparative disadvantage in that segment.

Similarly, a high mileage firm may find it profitable to use its CAFE credits building low mileage cars because of the CAFE induced rise in the price of those cars, even though another firm may be able to build those cars at a lower cost. Indeed, it is possible that a high mileage firm may have to expand into low mileage cars in order to survive. Consider an industry structure consisting of two types of firms. One type produces both high and low mileage cars and is bound by a CAFE standard. Thus, these firms must lower the price of their high mileage cars. They are able to do this and stay in business because they are making higher profits in the low mileage segment. If the other type of firms produce only high mileage cars they are at a serious disadvantage. They must sell their products in a market where their competitors are being subsidized by lucrative sales of large cars. Given this situation, a high mileage firm may have no choice but to expand into low mileage cars.

Thus, a binding CAFE standard creates what may best be described as regulatory economies of scope in the auto industry. No firm can legally be below the standard and no firm can afford to be above the standard. Therefore, in a regime of binding CAFE standards it could be expected that in the long run all firms in the industry will converge towards the CAFE standard. Thus, all firms will produce both large and small cars.

This result depends on three assumptions. First, standards must be binding. Second, CAFE credits must not be tradeable across firms. Third, it must be possible for all firms in one way or another to produce and sell cars that have mileage above the standard.

## IV. SIMULATION OF THE EFFECTS OF CAFE STANDARDS

This section will simulate the effects of various CAFE levels on the automobile market and on energy consumption. The model presented analyzes whether if enforcing CAFE standards is likely to have the perverse effects on industry profits, structure and employment, that Section III indicates are possible. It will also examine if CAFE standards do indeed save energy. The simulation will make a cost-benefit analysis of the decision faced by NHTSA for model years 1986 and 1987. If NHTSA had not granted the relief petitions, firms would have been forced to "mix-shift" in the manner described above to meet the standards. In the short period available to the firms to change their fleet MPG's, changing the fuel efficiency of various automobiles would not have been a viable option.

This section is divided into two parts. The first will analyze the results of a static model of CAFE standards. The effects of various binding CAFE levels industry profits, employment and structure will be calculated. The second part will generate any savings in gasoline that the results of the static model imply. It will chart the course of the fuel savings from the flow of new automobiles, adjusted for the changes induced by the imposition of CAFE standards, as well as the change in the stock of used automobiles due to the change in the price of new cars.

## Static Model

The comparative statics model used here is an extension of the 1985 Council of Economic Advisers model used to analyze the effects of import quotas on the total number of Japanese cars. Model year 1984 is used as the base period. In the model there are five types of automobiles: 1) Japanese Basic Small, which includes regular minicompacts and subcompacts such as the Sentra and the Corolla; 2) Japanese Luxury Small, which includes specialty subcompacts and regular compacts such as the RX7 and the Stanza; 3) American Basic Small, which includes minicompacts and subcompacts such as the Cavalier and the Escort; 4) American Luxury Small, which includes specialty subcompacts and regular compacts such as the Reliant K and the Mustang; 5) American Large, which includes intermediate and large cars such as the Cutlass and the LTD. Luxury European cars, which comprise about 3.5 percent of the market, are excluded from the model. Other European cars (Volkswagen-Audi and AMC-Renault) are included in the American segments. On-shore Japanese production is included in the Japanese segments.

Each segment is divided into constrained and unconstrained production. Constrained are Japanese imports (by the quota) and General Motors and Ford (by CAFE standards). Unconstrained production includes on-shore Japanese output, Chrysler, AMC- Renault, and Volkswagen (which under the nuances of CAFE regulation includes on-shore VW production, off-shore VW production, and Audi). "Captive" imports (autos built in Japan but sold under American nameplates) are included in the Japanese segments. The quantities, prices, and fuel efficiencies for each type of car for model year 1984, are shown in Table 1.[5]

Equilibrium prices and quantities are computed through a series of five demand and five supply equations. Quantity demanded is determined by a set of linear demand curves[6]

$$(4\text{-}1)\quad Q = AP + B$$

where Q a the vector of five quantities, P is the price vector, A is a five by five matrix of slope coefficients, and B is a vector of intercepts.

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[5] Actual final mileage figures are somewhat above those reported in Table 1. There are two possible reasons for this discrepancy. First, EPA mileage figures are subject to revision for CAFE regulatory purposes. Second, Ward's segment data are calculated through registration data for calendar, not model years. Data included in the 1985 yearbook includes some sales for model year 1985 (fourth quarter 1984), which could have reflected as increased consumer demand for large cars.

[6] With the imposition of a standard, linear curves generate less deadweight loss than constant elasticity curves.

Quantity supplied is determined by a set of linear supply curves

$$(4\text{-}2)\ Q = C(P-T) + DP + E$$

where C is a diagonal five by five matrix of supply coefficients for constrained firms, D a diagonal five by five matrix of supply coefficients for the unconstrained firms, E a vector of supply curve intercepts, and T is a vector of implicit taxes, $T' = (T_1, T_2, T_3, T_4, T_5)$. Note that T is only applied to constrained firms. $T_1$ and $T_2$ are the implicit tariffs for each type of off-shore Japanese car, $T_1$-$T_2$. $T_3$, $T_4$, $T_5$ are the implicit CAFE taxes applied to each type of American car produced by constrained firms GM and Ford.[7] The level of these taxes will be generated by the model.

During the 1980s, Japanese car sales in the United States have been restricted by import quotas (so-called "voluntary restraint agreements"). The implicit tariff generated by the quota is set at an initial level of $2400 and is assumed to be equal for each type of Japanese car. Given the elasticity assumptions of this model, a tariff of $2400 is consistent with Crandall [1984].[8] The quota is set at 1.85 million cars. CAFE standards are assumed to be just non-binding in the initial conditions and equally binding on the "Big Two" (General Motors and Ford) if the policy is enforced.[9] This is likely to yield an underestimate of deadweight loss, as DWL is a function of the implicit tax squared and Crandall [1986] suggests that even without relief CAFE standards would be binding on GM and Ford. If CAFE standards are imposed, they are assumed to be binding, and the implicit tax per "Big Two" car is calculated according to equation [3-33]. The system of 12 equations (five demand curves, five supply curves, and two constraints) in 12 unknowns (five quantities, five prices, and two implicit taxes) is solved and the implicit tariff and the shadow tax per MPG are iterated until the desired quota and CAFE standard level are reached.

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[7] Assume that under one scenario in the model the implicit tariff on Japanese cars is $2500 and the implicit CAFE tax is $300 per MPG. Using the formula for calculating implicit CAFE taxes (3-33) and the MPG per class in Table 1 yields an implicit tax vector T' = (2500, 2500, 300*27.5*((27.5/33.30)-1), 300*27.5*((27.5/26.72)-1), 300*27.5*((27.5/22.30)-1)) = (2500, 2500, -1437, 241, 1924).

[8] Assuming a supply elasticity of 2, a demand elasticity of 3.5, and an increase in the price of Japanese cars of $872 yields an implicit tariff of $2400. Crandall estimates the price impact of quotas for Japanese cars as being from $800 to $1000.

The point elasticities of demand at the original 1984 equilibrium are shown in Table 2. The own elasticity of demand for automobiles as a whole is assumed to be one. (This is consistent with the results reported in Irvine[1983].) It is assumed here that the demand for small cars is more elastic than the demand for large cars, though this is questioned by Langenfeld and Munger [1985]. The cross-elasticities shown are not meant to be accurate figures, but merely internally consistent. The method for the derivation of the cross-elasticities is presented in the technical appendix (which is available from the author).

To this author's knowledge, no study exists of short-run cost curves in the auto industry. Results of Friedlander et. al. [1983] indicate that the industry may have constant long-run marginal cost curves. In the short run, however, it seems likely that marginal costs are increasing. Thus, the point elasticity of supply (marginal cost) in the model is set equal to 2, which assumes that while the industry has a competitive structure, there are rents to be earned in the sale of automobiles.

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[9] Chrysler is assumed not to be bound by CAFE regulations in the simulation. Its supply of credits earned in previous years are more than sufficient to cover any likely shortfall.

## Results of Static Model

The most obvious conclusion to be derived from running the static model is that imposing CAFE standards can create tremendous losses for the economy. For instance, imposing an increase in fuel economy levels of 1.5 MPG costs the economy about $3.5 billion. This is of the same magnitude as the losses from import quotas on Japanese cars (See Crandall [1984]). As for winners and losers, it depends on how tight a CAFE standard is set.

## Effects of Firms, Autoworkers, and Consumers

Figure 1 shows the changes in profits for the Big Two companies, Chrysler, and the Japanese firms. It turns out that it is not all that unlikely for the constrained firms to have increased profits as a result of increased fuel economy levels. At CAFE-imposed fuel economy increases of below 0.9 MPG profits of GM and Ford rise, reaching a level of $144 million with an increase of 0.5 MPG. Viewed in this context, Big Two support for higher CAFE levels in the 1970s is not at all surprising.

Unfortunately for the Big Two, profits turn sharply negative after 0.9 MPG. At increases of 1.5 MPG the Big Two suffer losses of almost $500 million, and at 2.5 MPG their estimated regulation induced losses are over $2 billion. This would seem to explain why GM and Ford were so eager to gain relief for both model years 1985 and 1986.

The impact of CAFE regulations on Chrysler's profits are quite different. Chrysler loses a little money (at most $10 million) at low CAFE increase levels as increased Big Two small car sales lower the price Chrysler can gain for its small cars. However, at higher CAFE levels Chrysler's profits are sharply positive as Chrysler increases its sale of large cars while GM and Ford are severely constrained in that segment. A CAFE increase of 1.5 MPG raises Chrysler profits by $386 million, while an increase in CAFE levels of 2.5 MPG reaps a windfall of over $1 billion for the nation's number three automaker. This may explain why Chrysler is such a vocal supporter of CAFE standards.

Japanese firms did not produce any large cars and hence would seem to be more vulnerable in the short run to CAFE increases than Chrysler. With a CAFE increase of up to 1.1 MPG the Japanese lose money as GM and Ford lower small car prices. However, as CAFE standards rise above that level, more and more would-be large car buyers switch into Japanese luxury small cars, resulting in increasing Japanese profits. With a CAFE increase of 1.5 MPG the Japanese gain $313 million in profits, and at 2.5 MPG they make about $1.8 billion. Given the inherent range of error in a simulation like this one, it is not at all clear whether Japanese firms stand to gain from an increase in CAFE levels of 1.5 MPG.

Figure 2 illustrates the effects of higher CAFE levels on automobile industry employment. Potential gains for autoworkers through CAFE regulation appear to be quite small. At most, imposing a higher CAFE level results in an increase of only about 4000 jobs. However, as the CAFE levels increases, the effect on autoworkers turns sharply negative. With a CAFE increase of 1.5 MPG 37,900 jobs are lost, and imposing an increase of

2.5 MPG results in the loss of 121,900 jobs. Thus, while it is possible CAFE standards can serve as a means of domestic content legislation to protect industry jobs, they are more likely to reduce auto employment.

Figure 3 illustrates that consumers are the big losers when higher CAFE standards are imposed. An increase of 1.5 MPG leads to consumer losses of almost $3.4 billion, while an increase of 2.5 MPG costs consumers a staggering $8.8 billion. Oddly enough, at very low levels of CAFE increases, consumers, and the nation as a whole, actually benefit from the higher standards. What is occurring here is that the extraction of quota rents from Japanese firms outweighs the deadweight loss resulting from implicit CAFE subsidies and taxes.

Increasing Big Two CAFE levels by any significant amount generates large implicit taxes. Increasing CAFE by 0.5 MPG induces a shadow tax of $241 per MPG on Big Two cars. A CAFE increase of 1.5 MPG results in an implicit fuel efficiency tax of $646, while a shadow tax of $894 per MPG is required to increase Big Two CAFE levels by 2.5 MPG.

Not surprisingly, the fuel efficiency levels of non-constrained firms decrease as the CAFE levels of the Big Two increase. Non-constrained CAFE levels decline from 30.17 MPG to 29.43 MPG when the Big Two are forced to increase their CAFE levels by 2.5 MPG. The non-constrained firms expand their share in larger cars and decrease their presence in the small car market as higher CAFE levels are imposed. This can be taken as at least partial evidence that imposing CAFE standards creates economies of scope in the auto industry.

## Gasoline Consumption Model

To measure the gasoline savings from CAFE standards, it is necessary to trace the consumption of new cars sold under the standards for their entire lifespan and to compare that to the consumption that would take place without the imposition of CAFE standards. It is also necessary to take account of the "scrappage effect," the change in the stock of used cars that results from a change in the price of new cars. Several studies, such as Gruenspecht [1982] have found that scrappage rates of used cars are significantly affected by new car prices.

The average miles driven and the scrappage rates for automobiles for fifteen years after they are sold, obtained from surveys of the Department of Transportation, are used in the model. The scrappage rates are adjusted for new car prices changes using the average of Gruenspecht's results. Gruenspecht showed that if the price of new cars is raised (lowered), it causes a significant decrease (increase) in the scrappage rates of used cars. This effect was so large, in fact, that it was shown that imposition of more stringent pollution controls would actually cause pollution to increase. It is assumed that Gruenspecht's results hold for each of the three classes of automobiles (Basic Small, Luxury Small, and Large). For purposes of the consumption model Japanese cars are combined with their corresponding American segments.

Much of the fleet changes analyzed above from large car buyers switching into new cars due to the change in relative prices. Smaller cars, however, are more fuel efficient, which lowers the marginal cost of driving, which will encourage more driving. Blair et. al.'s [1984] estimate of this effect will be used to adjust the miles driven for the new cars coming onto the road. The values of MPG for the three classes can be determined from the information used in the static model. The entire fleet fuel efficiency for 1973 is known to be about 14.2 MPG. The model assumes that the ratio of fuel efficiencies between classes is the same for each year. With this assumption, knowledge of the fraction of cars in each class for 1973 and the entire fleet fuel efficiency for 1973, the fuel efficiency for each class of new car in 1973 can be calculated. It is also assumed that fuel efficiency grew exponentially for each class of car between 1973 and 1984. MPG's are then calculated accordingly. Fuel efficiency for cars made before 1973 is assumed to be equal to 1973 levels and fuel efficiencies after 1984 are assumed to be equal to 1984 levels.

## Results of Consumption Model

The gasoline consumption results are summarized in Figure 4. The simulation was run with the CAFE increase of 1.5 MPG in force for one year and with the additional scrappage and substitution effects described above for various CAFE levels. A discount rate of 4 percent is used.

As noted before, Kwoka hypothesized that CAFE standards could increase gasoline consumption by placing more cars on the road. Gruenspecht reached a similar conclusion when he showed that pollution standards could actually increase pollution levels by raising the price of new cars and hence decreasing the scrappage rates of old cars. Figure 4 shows that CAFE standards can indeed have such a perverse effect. CAFE level increases of up to 0.5 MPG do lead to small increases in gasoline consumption (no more than 43 million gallons out of an annual automobile consumption of about 60 billion). As CAFE standards grow tighter, fuel savings turn positive, reaching 712 million gallons at 1.5 MPG and 2.105 billion gallons with a CAFE increase of 2.5 MPG.

While CAFE policy can save gasoline, it does so at a prohibitive cost to the economy. The average cost per gallon saved with a CAFE increase of 1.5 MPG is $4.87, which declines slightly to $4.61 with a CAFE increase of 2.5 MPG.

It is not appropriate to compare the CAFE-imposed cost of saving gasoline with the cost of the gasoline being saved. If gasoline costs $1 per gallon and consumers give up 1 gallon of gasoline, consumers lose, at the margin, $1 worth of consumption. The loss per gallon noted here is in addition to this even tradeoff. (See Stucker et. al. [1980] at 61.) The true benefit from this policy is the reduction of the externality associated with gasoline consumption. This also implies that it is appropriate to discount future savings of gasoline in any cost-benefit analysis.

## Sensitivity Analysis

Given the need to make a large number of assumptions when establishing this model, it would be informative to see how the robust the conclusions of this paper are. The most important assumptions of the model are the relative elasticities of demand (whether demand for small cars is more or less elastic than the demand for small cars) and the elasticity of supply.

Table 3 shows the results of the model under various supply and demand elasticity conditions with an increase in CAFE of 1.5 MPG. Supply elasticities are set at 1.0, 2.0, and 4.0. A demand elasticity of "same" refer to the same demand elasticity being used as in the base case.

"Alternative" refers to alternative demand elasticities where the own elasticity of demand for small cars is reduced from 4.00 to 2.50 and the own elasticity of demand for large cars is increased from 2.50 to 4.00. New cross-elasticities are then computed using the different assumptions according to the method described in the technical appendix of this paper.

In five of the six scenarios examined GM and Ford lose a substantial amount of money, ranging from $234 million to $2.693 billion. Only when the supply elasticity is 4.0 (which given the circumstances of the industry would seem extremely high) and the basic scenario is used do they make money, and then only a bare $64 million.

The results for Chrysler are even more consistent. Chrysler makes money in every scenario examined, with profits ranging from $311 to $526 million. Thus, it would seem almost certain that enforcement of the higher standards results in a major windfall for Chrysler.

Japanese firms make money in five of the six scenarios, with profits ranging from $286 million to $1.903 billion. The most crucial factor for the Japanese is the elasticity of demand for large cars. If the large car elasticity is high, then many would be large car customers respond to higher prices by looking for alternatives. Japanese luxury small car prices rise in response to this additional demand, with resulting profits to Japanese firms.

The effect on consumers is always negative, with losses ranging from $2.347 billion to $4.646 billion. Auto industry employment declines as well, with from 25,600 to 59,00 workers being put out of work. From 532 million to 1.084 billion gallons of gasoline are saved, but at an exorbitant loss to the economy. Costs per gallon range from $3.71 to $6.29.

Thus, under a wide range of assumptions imposition of the higher CAFE standard saves gasoline at a large cost to consumers while benefitting Chrysler and Japanese firms. GM and Ford, would appear to lose millions and perhaps billions of dollars from higher standards while job losses in the auto industry measure in the tens of thousands.

## V. CONCLUSION

While CAFE standards were originally designed to decrease consumption of gasoline in this country, they can have other effects that perhaps were not considered by the authors of the legislation. By placing a check on competition in large cars, CAFE regulation can serve to increase the profits of constrained firms. CAFE standards can also increase domestic employment in the auto industry and actually increase consumption of gasoline. The simulation model presented in this paper shows that these perverse effects can occur, but with varying likelihood. Auto employment can increase slightly when CAFE standards are imposed, but is more likely to decline as the standard level increase.

Results for gasoline consumption are similar, as Kwoka's hypothesis is borne out only at only at CAFE imposed fuel economy increases of less than 0.6 MPG. What does come out of the simulations is that unconstrained firms, if they can adapt to the changed marketplace, have the opportunity to make a good deal of money as a result of CAFE standards. The profit possibilities in the large car market can outweigh the losses in the small car segment. Thus, CAFE regulation encourages and perhaps even forces all firms to produce each type of automobile, creating regulatory economies of scope in the industry.

## Table 1
## Initial Conditions - Model Year 1984

| | All Sales (mill.) | Non-Constrained Sales (mill.) | Price ($000) | Fuel Efficiency (MPG) |
|---|---|---|---|---|
| Japanese Basic Small | .900 | .000 | 7.60 | 37.24 |
| Japanese Luxury Small | 1.067 | .117 | 11.70 | 30.48 |
| U.S. Basic Small | 1.727 | .450 | 7.90 | 33.30 |
| U.S. Luxury Small | 1.859 | .559 | 10.00 | 26.72 |
| U.S. Large | 4.319 | .423 | 11.70 | 22.30 |
| Total | 10.100 | .939 | | 26.38 |

Sources: Ward's 1985 Automotive Yearbook, Environmental Protection Agency, Council of Economic Advisers

## Table 2

### Parameters Used in Static Analysis

Cross and Own Point Elasticities of Demand

| | Jpn. Bas. Sm. | Jpn. Lux. Sm. | U.S. Bas. Sm. | U.S. Lux. Sm. | U.S. Large |
|---|---|---|---|---|---|
| Japanese Basic Small | -4.000 | 0.867 | 3.105 | 1.209 | 1.075 |
| Japanese Luxury Small | 0.360 | -3.500 | 0.682 | 1.661 | 2.369 |
| U.S. Basic Small | 0.784 | 0.412 | -4.000 | 0.641 | 0.572 |
| U.S. Luxury Small | 0.230 | 0.755 | 0.482 | -3.500 | 1.672 |
| U.S. Large | 0.021 | 0.111 | 0.045 | 0.173 | -2.500 |

(The demand for each type of car is categorized by row. Thus, for example 0.867 (the value in the second row, first column) is a measure of how the demand for basic Japanese small cars will change with respect to a change in the price of Japanese luxury small cars.)

Point Supply Elasticities

| U.S. Production | Japanese Production |
|---|---|
| 2.0 | 2.0 |

Employment Factors (Cars per job)

| U.S. Production | | | On-Shore Jpn. |
|---|---|---|---|
| Bas. Sm. | Lux. Sm. | Large | Bas. Sm. |
| 8.1 | 7.3 | 6.6 | 21.0 |

## Table 3
## Results of Alternative Scenarios

**Imposing higher CAFE standard results in -**

| | | GM and Ford Profits ($billion) Supply Elasticities | | | Chrysler Profits ($billion) Supply Elasticities | | |
|---|---|---|---|---|---|---|---|
| | | 1.0 | 2.0 | 4.0 | 1.0 | 2.0 | 4.0 |
| Demand | Same | -2.122 | -0.497 | 0.064 | 0.479 | 0.386 | 0.311 |
| Elast. | Alternative | -2.693 | -0.934 | -0.234 | 0.526 | 0.421 | 0.327 |

| | | Jpn. Firms Profits ($billion) Supply Elasticities | | | Consumers' Surplus ($billion) Supply Elasticities | | |
|---|---|---|---|---|---|---|---|
| | | 1.0 | 2.0 | 4.0 | 1.0 | 2.0 | 4.0 |
| Demand | Same | 0.661 | 0.286 | -0.019 | -4.450 | -3.330 | -2.347 |
| Elast. | Alternative | 1.903 | 1.521 | 1.132 | -4.646 | -3.726 | -2.865 |

| | | Employment (000 jobs) Supply Elasticities | | | Gasoline Saved (bill.gallons) Supply Elasticities | | |
|---|---|---|---|---|---|---|---|
| | | 1.0 | 2.0 | 4.0 | 1.0 | 2.0 | 4.0 |
| Demand | Same | -52.428 | -38.247 | -25.652 | 0.971 | 0.743 | 0.532 |
| Elast. | Alternative | -59.024 | -47.878 | -37.764 | 1.084 | 0.886 | 0.694 |

| | | Cost Per Gallon ($) Supply Elasticities | | |
|---|---|---|---|---|
| | | 1.0 | 2.0 | 4.0 |
| Demand | Same | 6.28 | 4.63 | 3.71 |
| Elast. | Alternative | 6.29 | 4.89 | 4.00 |

For the demand elasticities "Same" refers to baseline case where own demand for large cars is assumed to be -2.50 and own demand for small cars is -4.00. "Alternative" refers to the alternative scenario where the two numbers are reversed and new cross-elasticities are computed using the different assumptions.

FIGURE ONE
CHANGE IN CORPORATE PROFITS

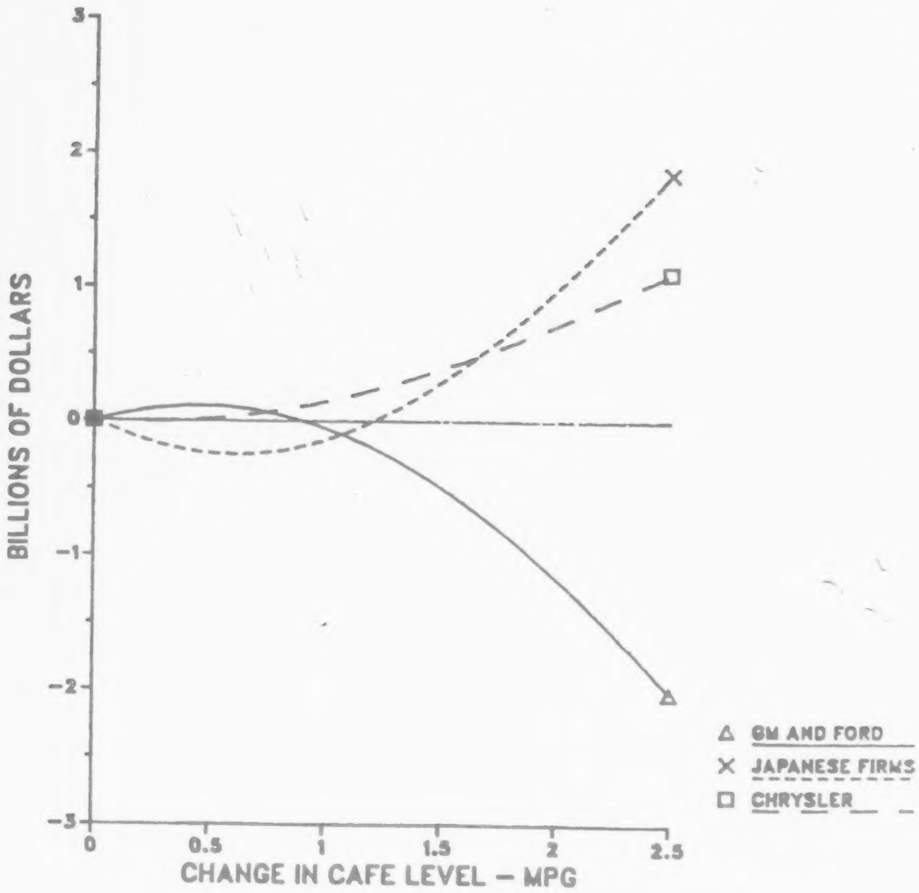
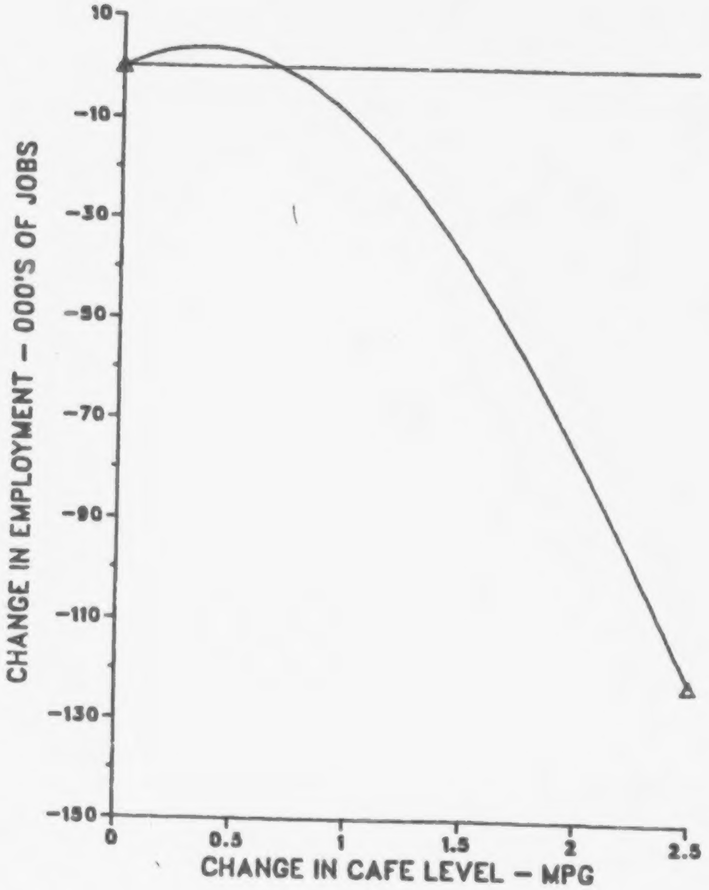


FIGURE TWO
CHANGE IN EMPLOYMENT



## FIGURE THREE
## CHANGE IN CONSUMER WELFARE

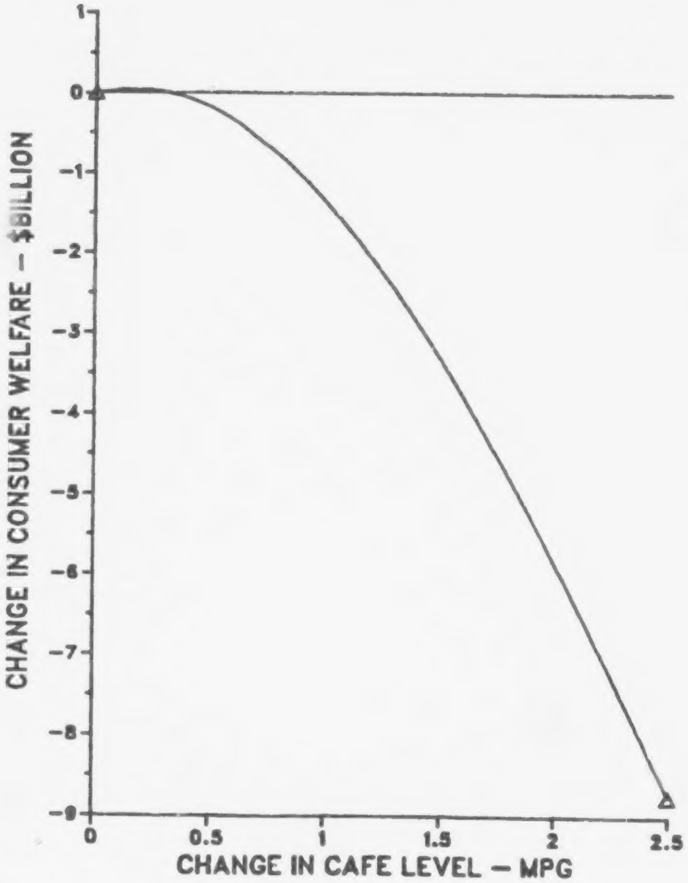
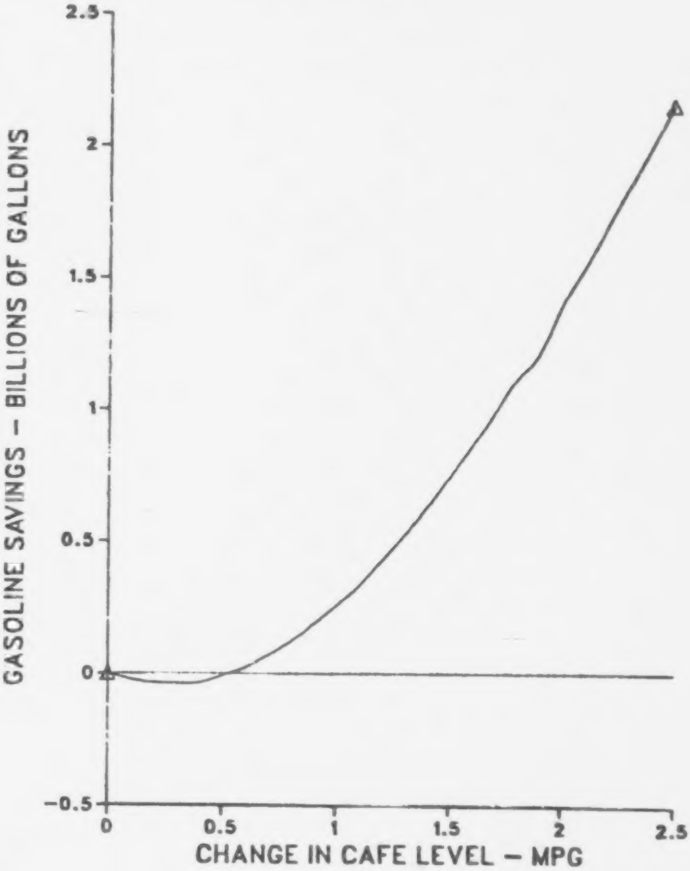


FIGURE FOUR
GASOLINE SAVINGS FROM CAFE



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# THE EFFECT OF FUEL ECONOMY STANDARDS ON AUTOMOBILE SAFETY

by

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## Introduction

In 1975 Congress passed the Energy Policy Conservation Act, which established mandatory fuel economy standards for all new automobiles sold in the United States beginning with the 1978 model year. These standards, called the Corporate Average Fuel Economy (CAFE) Standards, were then designed to increase the incentive for automobile producers to improve fuel efficiency beyond that dictated by market forces, which were being distorted by government controls on crude oil and refined products. By the 1985 model year, all automobile producers were to have achieved at least a 27.5 MPG rating for their automobiles.[1]

There has been a lively debate about the effectiveness of the CAFE program as a conservation measure and its effect upon the domestic automobile industry, particularly in light of the sharp decline in real gasoline prices since 1981.[2] However, we know of no quantitative investigations of the effects of this policy on other social goals, such as motor vehicle safety.[3] In this paper, we estimate the effects of the CAFE program on the average weight of new automobiles, the mix of large and small vehicles sold in the United States, and the ultimate effects of this new fleet size on vehicle safety. In so doing, we link economic models of the auto industry with a rich literature on the effects of vehicle weight on the susceptibility of occupants to injury and death. Our new empirical results suggest that CAFE will be responsible for several thousand additional fatalities over the life of each model year's cars. We conclude that the real social cost of government-mandated fuel economy is much greater than is commonly believed.

## The CAFE Program

Under the CAFE program, all automobile producers with sales in the U.S. market must meet a minimum average fuel-efficiency standard, defined as a harmonically weighted average of the city and highway EPA mileage ratings for all their cars. Companies that produce in the United States and import from other countries must satisfy this standard separately for their imported and for their domestic models.

The standard was set in the legislation at 18 miles per gallon for the 1978 model year, rising to 27.5 miles per gallon by the 1985 model year. The Department of Transportation (DOT) was responsible for setting the precise level of the standard for the 1981-84 model years and for 1986 and beyond. In addition, DOT may adjust the standards for changing conditions (such as changes in technological or economic feasibility). Failure to meet the standard results in civil penalties of $50 per MPG per car produced. Were General Motors to fail to meet the 1987 or 1988 standard by just 1.0 MPG, for example, it could be subject to penalties of $200 million per year or more.

The sharp rise in gasoline prices after the Iranian revolution provided automobile producers with sufficient market incentives to meet and even exceed the CAFE standards through 1981. All three major U.S. producers exceeded the standards by a wide margin (Table 1), building up credits that they could carry over for three years to cover any further shortfalls. As gasoline prices began to fall after 1981, the CAFE standards began to bind. By 1983 Ford and General Motors began falling short of the standard. At first they could use credits accumulated prior to 1983, when they exceeded the CAFE standard, to offset these shortfalls. By 1985, however, it was apparent that their shortfall for 1986 would be very large, inducing them to petition the Department of Transportation for a relaxation of the standard to 26 MPG, which was granted.[4] In a subsequent rulemaking, the 26 MPG standard was extended to the 1987-88 model years.[5]

With real gasoline prices in 1988 as low as the pre-OPEC era, pressure has been mounting for a revocation of the CAFE program altogether. Although the Reagan Administration appears to support revocation, resistance in Congress is substantial. CAFE is a program of trade restriction that some Congressmen from automobile-producing areas may be loathe to eliminate. Since CAFE forces U.S. manufacturers to meet a fuel efficiency standard for their domestic production alone, CAFE discourages them from importing low-cost small cars from Asia or Eastern Europe even though such a strategy may provide automobiles at the lowest cost to U.S. consumers. To meet CAFE while producing larger cars, they must produce small cars in the U.S.[6] CAFE is thus a program of trade restriction that some Congressmen from automobile-producing areas may be loathe to eliminate. Moreover, CAFE is more of a burden to Ford and General Motors than to Chrysler, since Chrysler has moved away from the production of the larger cars. This has led Chrysler to support the CAFE program aggressively while Ford and General Motors seek relief from it. And those who fear a sharp rise in gasoline prices in the next decade see CAFE as a prudent conservation policy.[7]

Unfortunately, little attention has been focused upon another aspect of the CAFE program. Fuel efficiency is most easily improved by reducing vehicle weight, but lower-weight vehicles tend to provide less crash protection to vehicle occupants than larger, heavier cars. In theory it may be possible to build lighter cars without compromising safety, but analysts have shown that the "downsized" vehicles of the late 1970s and early 1980s are less safe in crashes then the heavier cars they replaced.[8] As a result, by forcing U.S. producers to offer lighter cars, the CAFE program may be increasing the number of deaths and injuries on U.S. highways compared to the number that would occur without CAFE. This is a real social cost of pursuing fuel efficiency that policymakers have been reluctant to address. Indeed, the federal agency that administers the CAFE program, the National Highway Traffic Safety Administration, has done little to inform legislators and the public about the potentially adverse safety impacts of CAFE.[9]

## The Impacts of CAFE on Vehicle Weight

Since planning, designing, engineering, and tooling a new model requires at least four years,[10] automobile manufacturers must begin to plan to meet future CAFE standards based upon extremely uncertain forecasts of the level of gasoline prices in the years in which a model is actually sold. Moreover, they cannot know in advance how well any line of vehicles will survive in the marketplace. Thus, it is very likely that the average level of fuel efficiency realized by an automobile producer's full line of automobiles in any given year at its expected selling prices will deviate substantially from its plan. If the deviation is positive, the manufacturer may simply accumulate CAFE credits for future use in the event of shortfalls -- such as those GM and Ford have encountered since 1983. But if the deviation is negative at planned prices, the manufacturer may elect to raise large-car prices or large-engine option prices and lower the prices of smaller, less-powerful (and gas-consuming) cars.[11]

In short, it is the manufacturer's expectations of fuel prices and CAFE approximately four years in advance of the vehicle's production that is likely to influence the engine and vehicle-weight choices for individual models. Once these choices are locked in, the manufacturer can only use price (or non-price rationing) to meet CAFE if he finds that his planning has left him short of the standard or petition for a reduction in the CAFE standard.[12]

Much of the practical impact of CAFE in vehicle design has been upon the weight of automobiles. CAFE has affected the design of transmissions, the choice of ignition and fuel-injection systems, tires, and engine oils, but empirical analysis of the impact of all these "technical design" factors on CAFE suggests that they are only slightly more important than weight reduction.[13] Through materials substitution, improved design, and reduction of interior volume, manufacturers have greatly reduced vehicle weight and increased fuel efficiency.[14] As Table 2 demonstrates, the average U.S. automobile has undergone a 23 percent reduction in weight since 1974. With this reduction in weight, an even greater proportional reduction in engine size has occurred. The combined effect of these two reductions on fuel economy has been to raise MPG by about 24 percent.[15]

Our principal objective in this paper is to estimate the effect of CAFE on vehicle weight and, therefore, on vehicle safety. To accomplish this, we need to separate the effects of CAFE from those of the changing real prices of gasoline and materials. We then estimate the effect of this CAFE-induced reduction in weight on vehicle safety.

We begin with the producer's design decision for each individual car offered. The producer offers a number of different sizes of automobiles for different consumer tastes, but for each model he has a choice among materials, body designs, and engines. A lighter car, for a given size class, will provide greater fuel economy but perhaps by sacrificing the quality of the automobile's ride. Moreover, lighter cars may require more expensive materials to provide the same durability and performance as a heavier car. As the real price of steel rises, however, the cost of reducing weight to increase fuel economy becomes less onerous.

In designing and engineering each car, therefore, the producer will increase weight only up to the point where the additional value of that weight is offset by the incremental value of the loss in fuel efficiency. The design weight will vary inversely with both the expected price of motor fuel and the price of steel, by far the most important material in the automobile.

For each car, of size class S, we hypothesize that the vehicle producer will choose a weight (WT) that depends upon expected gasoline prices (PGASEXP) and expected steel prices (PSTEEL) four years prior to the sale of the car. Using a sample of all domestic sedans (n = 195) tested by Consumers' Union over the 1970-85 period, we first estimate a model of the determinants of automobile weight that takes the following loglinear form:

$$(1)\ \text{Log}\ WT_{it} = a_0 + a_j \sum_{j=1}^{4} S_{ji} + a_5\ \text{Log}\ PGASEXP(-4)_t + a_6\ \text{Log}\ PSTEEL(-4)_t + u_{it}$$

$$i = 1,\ldots,n(t)$$

$$t = 1970,\ldots,1985$$

$$\sum_{t=1970}^{1985} n(t) = 195$$

where u is a stochastic error term with zero mean and constant variance over the entire sample.

For the expected real price of gasoline, we use a commercial forecasting service's (DRI's) forecast of the next two years' expected rate of real price increase[16] for motor fuel cumulated for four years and multiplied by the real price index for gasoline lagged four years (because design decisions must be made four years before the model is offered). Unfortunately, we do not have an expected price series for steel and are forced to use a simple four-year lag on real steel prices. The size classes used for the four dummy variables ($S_j$'s) are COMPACT, INTERMEDIATE, FULLSIZE, and LUXURY, reflecting widely-accepted classifications in the industry.[17]

We initially assume that (1) applies uniformly to all size classes -- that is, that the trade-off between weight, steel prices, and fuel prices is the same for all size classes. The results from estimating (1) for the entire period appear in column (1) of Table 3. The estimated value of the coefficient for Log PGASEXP(-4) is low, suggesting an elasticity of weight with respect to anticipated gasoline prices of only -0.14. When the equation is estimated only for the pre-CAFE years, 1970-77, the estimated elasticity with respect to fuel prices rises to -0.54. Similarly, when the equation is estimated for only the 1970-81 period of rising gasoline prices, the elasticity with respect to gasoline prices remains at -0.54. A simple Chow test is suggestive of a change in structure between the 1970-81 sample and the 1982-85 sample of cars.[18] It thus appears that automobile producers adjusted vehicle weight to relative price expectations differently in the two periods -- presumably because of the binding constraint imposed by CAFE.

There appear to us to be at least two ways of attempting to measure the effect of CAFE on vehicle weight: insert a CAFE variable explicitly into (1); or use estimates of (1) from the preCAFE period to estimate weight and use the mean forecast errors as estimates of CAFE's effect. We try both.

To construct a variable reflecting CAFE's effect is obviously difficult. We choose the natural logarithm of the ratio of CAFE-mandated fuel efficiency to the 1975 average MPG for new cars, 15.79. (EPCA was passed in 1975.) This variable is represented as LogCAFE in Table 1. In the 1970-85 pooled cross-section time-series regression, LogCAFE takes on a value of zero prior to 1978 and the difference between the logarithm of CAFE in each year and the logarithm of 15.79. When it is included in the regression, column (2), its coefficient is -0.26 and statistically significant, but the coefficient of Log PGASEXP(-4) declines substantially. This suggests that in the 1980s, the vehicle manufacturers responded by reducing weight to meet the rapidly-escalating requirements of CAFE and not in response to fuel prices, as they had in the 1970-77 or 1970-81 period. Holding CAFE constant, the effect of changes in relative prices in 1982-85 appear not to have any effect on vehicle weight. Given the potential penalties of $50 per car per MPG for failing to meet CAFE, it is understandable that CAFE overwhelmed other influences on the producers' choice of vehicle weight in 1982-85.

When (1) is estimated for small cars only, the estimated elasticities of weight with respect to Log PGASEXP(-4) and Log CAFE increase somewhat, but the differences are rather small.[19] This suggests that CAFE had an effect on large cars as well as small cars during the post-1981 period of declining in real gasoline prices. Therefore, we use the estimates in Table 3 for all cars to measure CAFE's effect upon vehicle weight.

What is the effect of CAFE upon weight according to this approach? Our first approach to answering this question would be simply to set Log CAFE equal to zero for 1985 and solve for predicted weight. When this is done, the actual weight is 18 percent below predicted weight in 1985. Given that the average weight of new cars in 1985 was 3100 pounds, this suggests that CAFE has lowered weight by 611 pounds. Note that this approach assumes that the value of the coefficient of Log CAFE captures the regulatory effect, but this variable is constructed under the assumption that increments above 1975 MPG are totally induced by CAFE. In fact, it is probable that until gasoline prices turned down in 1981, the vehicle producers would have increased fuel efficiency substantially anyway. The coefficients of Log PGASEXP(-4) in 1970-77 and 1970-81 surely suggest such an explanation.

As an alternative and more satisfying approach to measuring the effect of CAFE, we use the 1970-77 and 1970-81 equations to forecast weight under the assumption that 1985 price expectations are fulfilled, that is, that the real price of gasoline stabilizes at 1985 expectations. These expectations could not be realized until the 1989 models. The forecast errors from such an exercise appear at the bottom of columns (3) and (4) in Table 3. They suggest a more modest effect of CAFE, about 11 percent, or about 360 pounds per car, assuming that 1985 fuel-price expectations are met in the 1989 model year and that the average weight of new passenger cars remains at 3100 pounds in 1989.

There is another data set that we can use to estimate the effects of CAFE on weight. EPA calculates the average fuel economy of new cars sold each year and the average weight of these automobiles. These average data for all new-car sales are available from 1968 through 1985.

The average weight of cars sold in each year is the product of the weights of each size class multiplied by the share of each size class actually purchased by consumers. As before, we assume that the real expected prices of gasoline and steel are the principal determinants of design weight, but we also need variables to explain the mix of vehicles actually purchased by consumers. Recent gasoline prices and income per capita may affect consumers' choices of vehicle size, as should the relative price of domestic and imported small cars.[20] Given the poor reputation of small domestic cars, an increase in imported small car prices (caused perhaps by currency changes) should induce consumers to shift toward relatively heavier U.S. cars.

The time-series model estimated therefore takes the form:

$$(2)\ \text{Log } WT_t = b_0 + b_1\text{Log } Y(-1)_t + b_2\text{Log } PGAS(-1)_t + b_3\text{Log } PSTEEL(-4)_t + b_4\text{Log } PGASEXP(-4)_t + b_5\text{Log } PDIFF(-1)_t + u_t$$

where WT is the average weight of cars of model year t, Y(-1) is real income per capita lagged one year, PGAS(-1) is the real price of gasoline lagged one year, PSTEEL(-4) and PGASEXP(-4) are as defined above, PDIFF(-1) is the difference between the U.S. prices for small Japanese cars and small U.S. cars, lagged one year, based upon a hedonic estimate of the value of attributes of U.S. cars in our Consumers' Union sample, and u is a random error term.[21]

The results of estimating (2) are shown in Table 4. Note that once again the estimated value of the coefficient of Log PGASEXP(-4) is much lower for the 1968-85 period than for 1968-81. When a separate variable for CAFE is included, as in the pooled, cross-section time-series estimates, its estimated coefficient is -0.287, remarkably close to the estimate in Table 3 above. However, for reasons detailed above, this probably attributes too much to CAFE.[22]

When Log PDIFF(-1) is included in the equation for the model years up to 1981, collinearity between PSTEEL and PDIFF arises, possibly because the value of the dollar is the most important determinant of each. As a result, adding Log PDIFF(-1) adds nothing to the explanatory value of (2). Hence, we use the estimates in Column (2), without Log PDIFF(-1), to project the average vehicle weight sans CAFE and calculate a forecast error assuming 1985 price expectations are met. The result is an average forecast for weight that is 14.2 percent too high, compared with the 11 percent mean estimate in Table 3 above. This suggests that the average weight of cars would be about 470 pounds lower due to CAFE in the 1989 model year if the average weight remains at 3100 pounds in the 1989 model year.

## The Effect of CAFE on Vehicle Size Class Mix

Automobile manufacturers may also have attempted to meet CAFE by inducing buyers to switch from larger cars to smaller cars. This only makes sense if the cost of inducing such a shift, including any difference in profits, is no greater than $50 per car times the difference in MPG. Over time, manufacturers may attempt to increase the appeal of their smaller cars, but in the short run, they can only use relative prices or non-price rationing to induce such a shift.

We have no data on the expenses incurred by U.S. automobile manufacturers to improve the ride or performance of their smaller cars so as to induce some customers to shift away from larger cars or from rivals' cars. However, we can attempt to estimate any short-run pricing response caused by a failure of manufacturers to predict the changing mix of cars demanded since 1981 when real gasoline prices began to decline. To do this, we estimate a hedonic model of automobile prices for 1970-77 from the Consumer Reports sample and use this equation to predict 1978-85 model-year prices. The proportional difference in mean predicted values for large and small cars may then be assumed to reflect a change in pricing strategy by the companies caused in large part by CAFE.

The hedonic model estimated is of the form:

$$(2)\ \text{Log } P = f\ (WT,\ ACCEL,\ HAND,\ RIDE,\ GASCOST,\ S,\ DY)$$

where P is the real list price of the vehicle for a standardized set of options, ACCEL is the time required for the car to accelerate from zero to 60 miles per hour, RIDE is a discrete variable for quality of the car's rise as estimated in road tests by Consumer Reports, HAND is a discrete variable for quality of handling from the same test, GASCOST is the real price of gasoline required for driving the car an average mile, DY are dummy variables for model years to capture the effects of other influences on the real price of autos, such as regulatory costs, and S and WT are as defined in (1) above.

The estimates of equation (2) for the 1970-77 period yield the following proportional prediction errors for small (subcompact and compact) cars and for large (intermediate and fullsize) cars in the 1978-85 model years:[23]

| Year | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 |
|---|---|---|---|---|---|---|---|---|
| Small | -0.021 | -0.054 | 0.000 | 0.167 | 0.127 | 0.123 | 0.062 | 0.040 |
| Large | -0.000 | -0.028 | 0.108 | 0.035 | 0.202 | 0.133 | 0.087 | 0.229 |

Note that the proportional prediction errors begin to grow in 1981, the first year of the voluntary restraint agreement (VRA) with Japan. At first, the error for the small cars is larger since the Japanese imports were predominantly smaller cars. After 1983, however, the prediction error for the large cars increases noticeably relative to the error for the smaller cars. By 1985, the results suggest that the large car prices were elevated 18 percent more than small car prices relative to historical patterns. We shall use this estimate as the effect of CAFE shortfalls on relative prices although it could have been larger given the impact of the VRAs on small car prices.

There are few studies of automobile demand that provide reliable estimates of cross elasticities of demand. Winston and Mannering estimate a logit model of type choice, but they do not report the cross-price elasticities of demand among various models from their estimates.[24] Toder estimates that the elasticity of the import share of U.S. automobile sales with respect to relative import prices is between -2.1 and -2.3.[25]

We assume that the cross elasticity of demand between "small" and "large" cars is 1.0. This assumption implies that by 1985, CAFE raised the proportion of small cars to large cars by about 18 percent. The average small car in our sample is 470 pounds lighter than a large car in 1985. Hence, the 18 percent shift may be assumed to have reduced average car weight for 1985 models by about 85 pounds.

## The Full Effects of CAFE on Vehicle Weight

To assess the effects of CAFE from our results, we must compare our predictions of vehicle weight under 1985 gasoline price expectations with actual vehicle weight when the 1985 model-design decisions are reflected on the market in the 1989 model year. Since this paper is being completed in 1988, we are forced to forecast the average weight of 1989 model-year cars about 1 1/2 years in advance.

A glance back at Table 2 suggests a very simple forecast -- that average passenger car weight will remain at approximately 3100 pounds. For eight years, there has been little change in average vehicle weight despite the sharp decline in real gasoline prices. Obviously, CAFE is a binding constraint on passenger car mix. Thus, we assume that the average passenger car will continue to weigh approximately 3100 pounds in the 1989 model year. This, in turn, suggests that CAFE will continue to reduce the average weight of new cars by 445 [360 + 85] to 555 [470 + 85] pounds in the 1989 model year, or an average of 500 pounds. How much would this lower weight affect highway safety? We now turn to this question.

## The Effect of Vehicle Weight on Safety

In research performed over the past fifteen years,[26] traffic safety analysts have found that occupants of lighter cars incur an elevated risk of serious injury and death in crashes compared to occupants of heavier cars. This statistical association has been demonstrated for both single-vehicle and multi-vehicle crashes. "Weight" is chosen as the independent variable in these investigations because it is both easily measured and strongly correlated with other vehicle attributes such as wheel-base, track, "size" in general, hood length, trunk size and engine displacement. Although the precise physical mechanisms by which weight (or its correlates) affect safety are not fully understood, the negative relationship between weight and occupant fatality risk is one of the most secure findings in the safety literature.

The most sophisticated research on the weight-safety relationship has been performed by Leonard Evans at General Motors' Research Laboratories. Based on a statistical model of car mass and real-world fatal crashes that holds constant driver behavior, Evans (1984) reports an empirical relationship of the form:

$$(3) \quad L(m) = \alpha \quad e^{-(0.00106)m}$$

where L(m) is the relative likelihood of fatality in a car of mass m (in kilograms).[27] Using this equation, we calculated that the 500 pound reduction in the average weight of 1985 cars that is attributable to CAFE is associated with roughly a 27 percent increase in occupant fatality risk.

This estimate should be regarded as an upper bound on the adverse safety effects of CAFE because it assumes that drivers of lighter cars do not realize the additional dangers and take precautionary responses. Some evidence reported by ORC (1980) and Winston, et.al. (1987) suggests, for example, that occupants of small cars are more likely to wear safety belts than occupants of large cars.[28] To account for the possibility of behavioral response, Evans (1982) reported results of an alternate statistical model that predicts the net effect of both vehicle size and behavioral responses on fatality risk.[29] His estimated equation is of the form:

$$(4) \quad L(m) = \alpha \quad e^{-(0.00058)m}$$

Using this equation, we calculated that CAFE is responsible for a 14 percent increase in occupant fatality risk in 1985 cars. In other words, drivers (and passengers) appear to offset about half of the physical disadvantages of lighter cars through various types of behavioral responses (for example, enhanced maneuverability and increased use of seat belts).[30]

Our rough estimate is therefore that the 500-pound or 14 percent reduction in the average weight of 1985 cars caused by CAFE is associated with a 14 to 27 percent increase in occupant fatality risk. This range does not account for a variety of second-order effects of CAFE on safety. First, if CAFE curtails overall car sales (as some evidence suggests is the case), that means that the older and predominantly heavier cars will stay on the road longer. Although that outcome might seem good for safety, one must also consider that the oldest cars in the fleet are not equipped with a variety of safety features (some mandated by NHTSA) that were initiated in the 1965-1975 period. Several studies have found that these safety features were quite effective.[31] We assume that these two effects cancel each other. Second, our rough estimates are based on models of the weight-safety relationship for single-vehicle crashes -- which NHTSA reports account for about one-half of occupant fatalities.[32] We have not performed separate calculations of the effects of lighter cars on fatalities in multi-vehicle crashes. Since the "weight effect" estimated by Evans is somewhat larger for multi-vehicle crashes, this omission will cause us to underestimate the overall adverse safety effects of CAFE.[33]

We are aware of only one line of reasoning that has been advanced that might undermine our result that CAFE is responsible for a substantial increase in occupant fatality risk. In their regulatory analysis of CAFE, NHTSA reports that the number of passenger car occupant deaths in the United States has been declining since 1980, even though the average weight of cars on the road has been declining.[34] They infer that the CAFE program must not be a significant detriment to safety. We question this line of reasoning. First, NHTSA analysts have shown that the number of passenger car occupant fatalities declined during this period because of the 1980 and 1982 recessions and the national campaign against drunk driving.[35] Second, the mere retirement of earlier, less safe cars should have reduced the fatality rate substantially. We submit that the decline in car occupant fatalities from 1980 to 1985 might have been more dramatic had CAFE not been in effect. Finally, the NHTSA analysis fails to address the fact that other variables -- such as rising real incomes -- tend to depress fatality rates over time. The motor vehicle fatality rate has been declining for decades for just this reason.

Our calculations based on Evans' work are furthermore consistent with results from national time-series models of highway fatalities.[36] These models suggest that total highway fatalities are inversely related to the average weight of cars on the road. In a regression analysis of U.S. fatalities over the 1947-81 period that included separate variables for income, speed, age of drivers, alcohol consumption, the average crashworthiness of cars on the road, the price of gasoline, the share of vehicle miles driven on limited access highways, the 55 MPH speed limit [55 MPH], and the share of truck miles in total vehicle miles, the estimated elasticity of fatalities with regard to vehicle weight was approximately -2.0.[37]

When the Crandall et.al. regressions are estimated using fatality rates (per mile) as dependent variables, the estimated elasticity of the occupant fatality rate with respect to weight varies from -1.2 to -2.3, depending upon whether one assumes speed is exogenous or endogenous (Table 5).[38] Similarly, the estimated elasticity of the total highway fatality rate varies from -3.0 to -3.8 in the regressions reported in Table 5.

As a final check on the various estimates of the contribution of weight to reducing serious injury and fatality rates, we include a breakdown of the 1987 data on model-specific injury rates calculated by the Highway Loss Data Institute (HLDI) from casualty insurers' data.

HLDI calculates injury rates and serious injury rates for each domestic and imported car. Its 1987 data reflect the results for 1984-86 models, or only 1985-86 or 1986 models if there have been model changes in the 1985 or 1986 model years. These data[39] and the average weight in each category are shown in Table 6 for all two-door and four-door sedans in the HLDI tabulation. The average injury rate is adjusted by HLDI for differences in average driver characteristics (such as driver age); hence, it is intended to represent the differences in the actual incidence of injuries caused by car characteristics.

It is absolutely clear from Table 6 that the larger cars have much lower injury rates. A simple regression analysis reveals that the elasticity of the injury rate and the serious injury rate with respect to weight is very close to -1.0 and that, with weight held constant, imports are safer on average. These results provide substantial support for the theory that weight is an important determinant of auto safety and that the elasticity of serious injuries with respect to weight is about -1.0.

Given the variation in the above results, we calculated the effect of CAFE on fatalities for a range of elasticities between -1.0 and -2.0. The projected 500 pound weight reduction in 1989 model year cars is equal to approximately 14 percent of the 3600 pound average weight of new cars in the absence of CAFE. If the average weight of all cars on the road were reduced by 14 percent, the time-series results predict a corresponding increase in the occupant fatality rate of 14 to 28 percent. The range from 14 to 28 percent includes the 14 to 27 percent range estimated from Evans' work, which we regard as the most reliable.

## Quantifying the Omitted Social Cost of CAFE

To provide a national estimate of the safety-related costs of CAFE, we forecasted the fatality toll for just one model year cars over its expected ten-year life. This provides a neat analysis that ignores the effect of CAFE on the mix of older cars on the road. If CAFE induces manufacturers to offer smaller cars and greater fuel economy than an unregulated industry would offer, it will undoubtedly lead to some postponement of the replacement of older, larger cars. These older cars are less safe than newer models of the same weight but may be more crashworthy than the prospectively smaller 1989 cars. We simply ignore these second-order transitional effects of CAFE.

In calendar year 1985 there were about 25,000 car occupant fatalities in a fleet of 130 million vehicles, which translates into 1.9 fatalities per 10,000 cars.[40] If we assume that a model year of car sales averages about 11.2 million, and if these cars experience this fatality rate through their ten-year life, and if 4 percent of the remaining 1989 models are scrapped each year, there will be a total of 17,800 fatalities in these cars. Without CAFE we estimate that the fatality toll would be much smaller, 13,900 to 15,600. In sum, CAFE is estimated to be responsible for 2,200 to 3,900 excess occupant fatalities over ten years of a given model year's use.

It is plausible to believe that the inverse relationship between car weight and safety also holds for serious nonfatal injuries. NHTSA (1985) estimates that the frequency of "serious nonfatal injuries" among car occupants is about five times larger than the frequency of fatalities.[41] Hence we estimate that CAFE will also be responsible for an additional 11,000 to 19,500 serious nonfatal injuries to occupants of the prospective 1989 model cars. A "serious" injury is defined as a score of 3 or greater on the American Association of Automotive Medicine's (six-point) Abbreviated Injury Scale. Typical "serious" cases include compound fractures and internal organ injuries.

These adverse safety outcomes can be converted to dollars using market estimates of the value of safety.[42] At a conservative value of $1 million per statistical life and $20,000 per statistical injury, the adverse safety effects of CAFE translate into a social cost of $2.4 to $4.3 billion over the life of 1989 cars. Assuming a real discount rate of 5 percent, the present value of CAFE's safety costs equal $1.9 to

$3.4 billion for the assumed ten-year life of 1989 model-year automobiles.

## A Cost-Benefit Calculation

We have estimated that abolition of the CAFE program (with sufficient lead time) would have led to a 500 pound increase in the average weight of a 1989 model year automobile and a reduction of 2,200 to 3,900 fatalities over a ten-year life of these cars. These lighter cars would, however, consume less fuel over this ten-year period, thereby offsetting some of the welfare loss of the higher vehicle fatality rate.

A 500 pound increase in average vehicle weight represents a 16.1 percent increase in the weight of 1985 model year cars. Crandall, et.al., found that the elasticity of MPG with respect to weight is between 0.7 and 0.8;[43] therefore, MPG would have been 11.3 to 12.9 percent lower and the cost per mile would have been 12.7 to 14.8 percent higher without CAFE for 1989 automobiles. Most estimates of the long-run elasticity of demand for travel are clustered around -0.50.[44] As a result, we may conclude that total travel in 1989 automobiles would have been about 6.4 to 7.4 percent less, without

CAFE, all other things equal.[45] The effect upon annual gasoline consumption would be equal to 1.076 to 1.087 times the consumption with CAFE in place. In short, CAFE saved 5.5 to 6.3 percent of gasoline consumed by 1989 models.

Assuming a 5 percent real social discount rate, an annual consumption of 500 gallons per 1989 model per year with CAFE and a price of gasoline equal to $1 per gallon in 1989, the present value of the gasoline saved by CAFE over ten years (assuming constant real gasoline prices) would be $2.4 to $2.8 billion for all 11.2 million cars sold or $1.8 to $2.2 billion for all 1989 automobiles except the Japanese imports that are presumably not affected by CAFE. In short, the savings of gasoline are not significantly larger than our estimate of the lost value due to increased highway injuries and fatalities.

## Further Considerations

It is not our purpose to provide a full cost-benefit analysis of the CAFE program, but we cannot leave the reader with the impression that the appropriate measure of the social value of CAFE is the difference between fuel saved and the added costs of reduced highway safety. Obviously, the CAFE program forced vehicle manufacturers to invest more resources in developing fuel efficiency than 1985 gasoline prices warranted. Indeed, we have shown that it was CAFE, not the price of gasoline, that drove average MPG in the 1978-85 period.

The excessive investment in fuel efficiency added substantially to the social cost of CAFE. In Crandall, et al., the elasticity of vehicle cost with respect to MPG was estimated to be approximately 0.35.[46] In a 1977 analysis of the prospective compliance costs of CAFE, the Department of Transportation estimated that raising average fuel economy from 20.5 to 27.6 would cost between $362 and $407 (1977 $) per car, or about 6.0 to 6.6 percent of the average price of a car in 1977.[47] This suggests a cost elasticity with respect to MPG of between 0.16 and 0.18. Even using this lower ex ante estimate, the excess compliance costs of CAFE may be estimated to be 0.6 to 0.7 of the cost of a passenger car for each additional MPG. At a price of $15,000 per car, the cost of each MPG for a given model year's cars is $1 billion. In short, the search for technologies to meet CAFE can be very expensive and easily swamp the fuel savings generated by CAFE.

The CAFE program also results in a mix of cars that is less desirable than those that would be produced for 1985 gasoline prices, thereby reducing the number of vehicles sold. This, in turn, translates into a deadweight loss since society foregoes the additional output that is valued above the incremental costs of production. And this reduction in new vehicles creates another social cost -- the extension of the useful life of older, less safe, and higher-pollution cars. In short, the full costs of the CAFE program are likely to be considerable even if one excludes the direct safety effect.

## Conclusion

Earlier analyses of the effects of fuel-economy regulation have missed an important point. Fuel economy regulation inevitably leads to smaller, lighter cars that are inherently less safe than the cars that would be produced without a binding fuel economy constraint. We have shown that even if the pursuit of fuel economy were costless to producers, the cost of the added loss of life and serious injury from traffic fatalities would more than offset its benefits in reductions of gasoline consumption for 1989 model year cars. We estimate that these 1989 model year cars will be responsible for 2,200 to 3,900 additional fatalities over the next ten years because of CAFE. Thus, when any discussion of energy conservation focuses upon the externalities in energy consumption, we would suggest that all such externalities be included. When safety considerations are included, CAFE appears to be a very costly social policy.

## FOOTNOTES

[*] This research was supported in part by a grant to the New England Injury Prevention Research Center by the U.S. Centers for Disease Control. The authors are grateful for useful comments from Steven Garver, Lawrence Summers, Clifford Winston, Sam Peltzman and anonymous referees.

1. Energy Policy and Conservation Act of 1975 (89 Stat. 902).

2. For a history of the issue, see National Highway Traffic Safety Administration, "Passenger Automobile Average Fuel Economy Standards for Model Years 1987-88; Final Rule," Federal Register, Vol. 51, October 6, 1986, pp. 35594-35599.

3. This issue has been raised, however, in a recent court suit challenging NHTSA's 1986-87 model year CAFE standards. See CEI v. NHTSA (DC Cir. #86-1646).

4. Federal Register, Volume 50, p. 40528 (1985).

5. Federal Register, Volume 51, p. 35594 (1986).

6. For an analysis of the possibly perverse effects of CAFE, see John Kwoka, "The Limits of Market-Oriented Regulatory Techniques: The Case of Automotive Fuel Economy," Q. J. Econ., November 1983, pp. 695-704.

7. It is possible to argue that the marginal social cost of imported oil is above its price because of a terms-of-trade effect. If this is true, CAFE may arguably serve as a substitute for an import fee even though it applies only to motor fuel consumed by new cars. Clearly, a program of reducing all oil consumption by a uniform tax (not just an oil import fee) is a preferable policy.

8. See, for example, I.S. Jones and R.A. Whitfield, "The Effects of Restraint Use and Mass in 'Downsized' Cars," SAE Paper No. 840199, February 1984.

9. Smaller cars may be more maneuverable, but this increase in maneuverability does not offset the increased risk of fatality in smaller cars. See the discussion below.

10. Energy and Environmental Analysis, The Technology/Cost Segment Model for Post-1985 Fuel-Economy Analysis. [Report prepared for U.S. Department of Transportation, 1981.], Chapter 3.

11. See the evidence on the pricing effect at pp. _____ below.

12. Ford and General Motors have succeeded in getting the Department of Transportation to reduce CAFE from 27.5 MPG to 26.0 MPG for model years 1986-88.

13. Robert W. Crandall, Howard K. Gruenspecht, Theodore E. Keeler, and Lester B. Lave, Regulating the Automobile, Brookings Institution, Washington, D.C., 1986, Chapter Six, pp. 117-140.

14. See James A. Wilcox, "Automobile Fuel Efficiency: Measurement and Explanation," Econ. Inquiry, Vol. 22, July 1984, pp. 375-385.

15. Crandall, et.al., op.cit.

16. The forecasts are available only for 1973-1985 and extend only for two years plus the remainder of the current year. As a result, we are forced to use the two-year forecast to estimate gasoline prices four years into the future. For the years prior to 1973, we use the actual real fuel price, thereby assuming that expectations were realized in 1970-72.

17. The size class Subcompact, is suppressed because the equation estimated has a constraint term.

18. It is impossible to reject the hypothesis of no change in structure because our pooled time-series cross-section coefficients are inefficiently estimated. Nevertheless, the coefficients are unbiased and consistent with our other results below.

19. The estimated elasticity of weight with respect to expected gasoline for small cars (SUBCOMPACT, COMPACT, and INTERMEDIATE) is -0.64 for 1970-77 and -0.68 for 1970-81 as compared with -0.54 for all cars as reported in Table 3.

20. Attempts to include other demographic variables in (2) did not prove successful.

21. The variables that account for the size-class mix are lagged one year because model years begin roughly 3 to 4 months before the calendar year and it is reasonable to expect some lag between changes in underlying economic variables and consumers' purchases of a major durable good.

22. Since we do not use the results in column (3) of Table 4 for estimating the effects of CAFE, we are not concerned about the serial correlation implicit in a Durbin-Watson statistic of 1.473.

23. The estimated equation (with t-statistics in parentheses) is:

$$\text{LogP} = 7.02 + \underset{(3.72)}{0.0002\ \text{WT}} + \underset{(0.49)}{0.002\ \text{ACCEL}} + \underset{(2.72)}{0.063\ \text{RIDE}}$$

$$- \underset{(0.66)}{0.931\ \text{GASCOST}} + \underset{(0.57)}{0.009\ \text{HAND}} + \underset{(1.69)}{0.051\ \text{COMPACT}}$$

$$+ \underset{(2.43)}{0.105\ \text{INTERMEDIATE}} + \underset{(2.53)}{0.147\ \text{FULLSIZE}} + \underset{(11.65)}{1.089\ \text{LUXURY}}$$

$$+ \underset{\text{(DUMMIES)}}{\ldots\ \text{TIME}} \qquad \bar{R}^2 = 0.900$$

24. Fred Mannering and Clifford Winston, "A Dynamic Empirical Analysis of Household Vehicle Ownership and Utilization," Rand J. of Econ., Summer 1985, pp. 215-36.

25. Eric J. Toder, Trade Policy and the U.S. Automobile Industry, Praeger, 1978.

26. The key papers in this literature are as follows: B. O'Neill, M. Ginsburg, and L. Robertson, "The Effects of Vehicle Size on Passenger Car Occupant Death Rates," SAE Paper 770808, September 1977, 6 pp.; J.R. Stewart and J.C. Stutts, "A Categorical Analysis of the Relationship Between Vehicle Weight and Driver Injury in Automobile Accidents," Final Report, Highway Safety Research Center, University of North Carolina, HSRC PR60, May 1978, 88 pp.; Small Car Safety in the 1980s, U.S. DOT, NHTSA, March 1981, DOT HS 805 729, 148 pp.; H.C. Joksch and S. Thoren, "Car Size and Occupant Fatality Risk, Adjusted for Differences in Drivers and Driving Conditions," Report to AAA Foundation for Traffic Safety, January 1984, CEM Report No. 4308-754, 36 pp.; I.S. Jones and R.A. Whitfield, "The Effects of Restraint Use and Mass in 'Downsized' Cars," SAE Paper No. 840199, February, 1984, pp. 41-51; and L. Evans, "Car Size and Safety: Results from Analyzing U.S. Accident Data," Proceedings of the Tenth Technical Conference on Experimental Safety Vehicles, Oxford, England, July 1985, pp. 548-556.

27. Leonard Evans, "Driver Fatalities versus Car Mass Using a New Exposure Approach," Accident Analysis and Prevention, vol. 16, 1984, p. 19-36.

28. See Opinion Research Corporation, Safety Belt Use Among Drivers, Final Report to U.S. DOT, NHTSA, DOT-HS-806-398, May 1980, p. 10 and Clifford Winston, Blind Intersection? Policy and the Automobile Industry, Brookings Institution, Washington, D.C., 1987, p. 76.

29. Leonard Evans, "Car Mass and Likelihood of Occupant Fatality," SAE Technical Paper Series 820807, 1982.

30. This behavioral response is consistent with the theory of "risk compensation" advanced by Sam Peltzman in "The Effects of Automobile Safety Regulation," JPE (Vol. 83), August-September 1975, pp. 677-725.

31. See Crandall et al. (1986), Chapter 6; Robert W. Crandall and John D. Graham, "Automobile Safety Regulation and Offsetting Behavior: Some New Empirical Estimates," American Economic Review, vol. 74, May 1984, pp. 328-331; and John D. Graham, "Technology, Behavior, and Safety: Am Empirical Study of Automobile Occupant Protection Regulation," Policy Sciences, Vol. 7, 1984, pp. 141-151.

32. National Highway Traffic Safety Administration, National Accident Sampling System 1984, U.S. Department of Transportation, Washington, D.C., DOT-HS-806-867, November 1985.

33. CAFE has resulted in lighter cars being sold in the period following 1981 than would otherwise have been sold. These lighter cars are more vulnerable to crashes with older, heavier cars as well as with vans, buses, and trucks.

34. See NHTSA, 1986, p. 35612.

35. James C. Fell and Terry Klein, "The Nature of the Reduction in Alcohol in U.S. Fatal Crashes," SAE Paper No. 860038, 1986.

36. See Crandall _et al_. (1986), chapter 4, pp. 45-84.

37. _Ibid_.

38. The variables in Table 5 are thoroughly explained in Crandall, _et al._, Table 4-4. The dependent variables are the ratio of passenger-car occupant fatalities to total passenger-car miles of travel (in hundred millions per year) and the ratio of total motor-vehicle fatalities to total motor vehicle miles traveled per year. SAFETY is a weighted index of the estimated safety of the stock of passenger cars on the road that declines with increased safety. WEIGHT is the average weight of cars on the road. INCOME is the average real earned per capital income for those aged 15 and older (000 of 1977$). YOUTH is the ratio of 15-25 year-old drivers to total drivers. ALCOHOL is total alcohol consumption per person of drinking age. TRUCKS is the share of vehicle miles accounted for by driving off-peak hours. COST is the real weighted average cost of an accident (hospital care, doctors' services, and auto repair CPI indexes deflated by the overall CPI-U). LIMITED ACCESS is the share of vehicle miles amassed on limited access highways. 55 MPH is a dummy variable with the value of zero before 1974 and unity thereafter. PFUEL is the deflated real price of motor fuel from the CPI.

39. We only show the injury rate because the data on serious injury rates are less complete. However, the two series evidence the same weight-injury relationship.

40. National Safety Council, Accident Facts, various years; Motor Vehicle Facts and Figures 1986, 1987, p. 19.

41. See NHTSA (1985), p. 16.

42. W. Kip Viscusi, "The Valuation of Risks to Life and Health: Guidelines for Policy Analysis, in Benefits Assessment: The State of the Art, J.D. Bentkover, V.T. Covello, and J. Mumpower, eds., D. Reidel Publishing Company, 1986, pp. 193-210.

43. Crandall et al., (1986), chapter six.

44. See Mannering and Winston, op.cit., and Carol A. Dahl, "Gasoline Demand Survey," The Energy Journal, January 1986, pp. 67-82.

45. This reduction in miles traveled will in turn reduce fatalities somewhat but also reduce the rate of replacement of older cars.

46. Ibid.

47. The Final Impact Assessment of the Automotive Fuel Economy Standards for Model Years 1981-84 Passenger Cars, U.S. DOT, NHTSA, Washington, D.C., 1977.

Table 1. The CAFE Standard, Domestic Manufacturers' CAFE Ratings, and the Price of Motor Fuel, 1981-86 Model Years

| MODEL YEAR | STANDARD | MANUFACTURERS' EPA MPG Ratings: | | | REAL PRICE* of motor Fuel (1967=100) |
|---|---|---|---|---|---|
| | | Chrysler | Ford | GM | |
| 1975 | -- | -- | -- | -- | 106.0 |
| 1976 | -- | -- | -- | -- | 104.3 |
| 1977 | -- | -- | -- | -- | 103.7 |
| 1978 | 18.0 | 18.4 | 18.4 | 19.0 | 100.5 |
| 1979 | 19.0 | 20.4 | 19.1 | 19.1 | 122.2 |
| 1980 | 20.0 | 22.1 | 22.6 | 22.4 | 149.6 |
| 1981 | 22.0 | 26.7 | 23.9 | 23.7 | 150.8 |
| 1982 | 24.0 | 27.6 | 25.0 | 24.6 | 134.7 |
| 1983 | 26.0 | 27.0 | 24.3 | 24.0 | 126.1 |
| 1984 | 27.0 | 27.8 | 25.8 | 24.9 | 119.2 |
| 1985 | 27.5 | 27.9 | 26.3 | 25.5 | 116.0 |
| 1986 | 26.0** | 27.8 | 27.0 | 26.6 | 88.9 |
| 1987 | 26.0** | 27.6 | 26.8 | 26.4 | 95.9 |

* CPI for motor fuel divided by the CPI-U for all items, calendar year

** Reduced by D.O.T.

Source: NHTSA; Bureau of Labor Statistics, CPI

Table 2. Average Weight and Engine Displacement, New Passenger Cars 1970 - 1987 Model Years

| Year | Weight (lbs) | Engine Displacement (cu. in.) |
|---|---|---|
| 1970 | 3877 | 297 |
| 1971 | 3887 | N.A. |
| 1972 | 3942 | 292 |
| 1973 | 3969 | 286 |
| 1974 | 3968 | 289 |
| 1975 | 4058 | 288 |
| 1976 | 4059 | 287 |
| 1977 | 3944 | 279 |
| 1978 | 3589 | 251 |
| 1979 | 3485 | 238 |
| 1980 | 3101 | 188 |
| 1981 | 3076 | 182 |
| 1982 | 3054 | 175 |
| 1983 | 3112 | 182 |
| 1984 | 3099 | 179 |
| 1985 | 3094 | 177 |
| 1986 | 3066 | 171 |
| 1987 | 3077 | 167 |

Source: R.M. Heavenrich, J.D. Murrell, and J.P. Cheng, "Light Duty Automotive Trends Through 1986," SAE Technical Paper Series, #871088, 1987; "Light Duty Automotive Trends Through 1984," SAE Technical Paper Series, #840499, 1984.

Table 3. The Determinants of Automobile Weight, Pooled Cross Section-Time Series Data, 1970 - 85 (All Sedans), [t-statistics in parentheses]

Dependent variable: Logarithm of WT

| Variable\Period | 1970-85 | 1970-85 | 1970-77 | 1970-81 |
|---|---|---|---|---|
| Constant | 8.096 | 7.939 | 8.346 | 8.222 |
| COMPACT | 0.240 | 0.237 | 0.250 | 0.254 |
| | (12.31) | (12.44) | (10.65) | (11.69) |
| INTERMEDIATE | 0.363 | 0.369 | 0.422 | 0.406 |
| | (17.66) | (18.28) | (17.06) | (16.70) |
| FULLSIZE | 0.524 | 0.519 | 0.574 | 0.551 |
| | (24.65) | (24.87) | (24.34) | (23.91) |
| LUXURY | 0.603 | 0.604 | 0.529 | 0.512 |
| | (10.68) | (10.95) | (6.24) | (5.62) |
| Log PGASEXP(-4) | -0.140 | -0.032 | -0.538 | -0.535 |
| | (4.30) | (0.68) | (3.57) | (3.70) |
| Log PSTEEL(-4) | -0.462 | -0.239 | -0.235 | 0.219 |
| | (5.23) | (2.12) | (0.67) | (1.02) |
| Log CAFE | | -0.263 | | |
| | | (3.12) | | |
| $\bar{R}^2$ | 0.823 | 0.831 | 0.856 | 0.829 |
| No. of Observations | 195 | 195 | 112 | 143 |
| Forecast Error | | | -0.115 | -0.105 |

Table 4. The Determinants at the Average Weight of New Automobiles, Time-Series Data, 1968-85 [t-statistics in parentheses]

Dependent variable: Logarithm of WT

| Dependent Variable | 1968-85 | 1968-81 | 1968-85 |
|---|---|---|---|
| Constant | 11.03 | 10.73 | 9.475 |
| | (9.72) | (8.54) | (7.63) |
| Log Y(-1) | -0.278 | -0.234 | -0.117 |
| | (2.20) | (1.69) | (0.87) |
| Log PGAS(-1) | -0.147 | -0.156 | -0.050 |
| | (1.63) | (1.47) | (0.55) |
| Log PSTEEL(-4) | -0.474 | -0.207 | -0.415 |
| | (3.25) | (0.651) | (3.14) |
| Log PGASEXP(-4) | -0.116 | -0.307 | -0.0080 |
| | (3.03) | (1.61) | (0.13) |
| Log CAFE | | | -0.287 |
| | | | (2.14) |
| $\bar{R}^2$ | 0.909 | 0.845 | 0.929 |
| DW | 1.315 | 1.804 | 1.473 |
| Forecast Error | | -0.1417 | |

Table 5. Estimates of the Determinants of Highway Fatality Rates, 1947 - 1981 (t - statistics in parentheses)

| | Occupant Death Rate | | Total Death Rate | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| CONSTANT | 17.7<br>(3.21) | 11.2<br>(1.50) | 25.2<br>(4.39) | 32.6<br>(4.89) |
| SAFETY | 2.10<br>(9.78) | 2.20<br>(9.15) | 1.73<br>(7.69) | 1.38<br>(6.87) |
| WEIGHT | -2.30<br>(3.74) | -1.22<br>(1.26) | -2.97<br>(4.61) | -3.83<br>(4.42) |
| INCOME | 0.848<br>(3.39) | 0.784<br>(3.30) | 0.598<br>(2.28) | 0.787<br>(3.75) |
| YOUTH | -0.170<br>(0.77) | 0.162<br>(0.50) | 0.333<br>(1.45) | 0.257<br>(1.00) |
| ALCOHOL | -0.190<br>(0.61) | 0.00898<br>(0.07) | 0.00806<br>(0.02) | -0.471<br>(1.67) |
| TRUCKS | 0.678<br>(5.15) | 0.707<br>(4.59) | 0.356<br>(2.58) | 0.447<br>(3.85) |
| SPEED | 0.463<br>(1.21) | --- | 0.0686<br>(0.17) | --- |
| COST | 0.849<br>(1.50) | 0.091<br>(1.58) | 0.0955<br>(1.61) | 0.109<br>(2.12) |
| LIMITED ACCESS | -0.109<br>(6.54) | -0.118<br>(5.32) | -0.115<br>(6.60) | -0.0834<br>(4.78) |
| 55 MPH | --- | -0.0853<br>(1.69) | --- | -0.00501<br>(0.11) |
| PFUEL | --- | 0.126<br>(1.26) | --- | -0.142<br>(1.74) |
| $\bar{R}^2$ | 0.991 | 0.992 | 0.991 | 0.992 |
| $\rho$ | -0.185 | -0.097 | -0.180 | -0.594 |

Table 6. Injury Experience, 1984-86 Models: Two-Door and Four-Door Sedans

| | TWO DOOR SEDANS | | FOUR DOOR SEDANS | |
|---|---|---|---|---|
| | Average Weight (lbs) | Average Injury Rate (avg=100) | Average Weight (lbs) | Average Injury Rate (avg=100) |
| Small Cars | 2243 | 125.8 | 2300 | 125.9 |
| Medium Cars | 2768 | 94.2 | 2754 | 106.0 |
| Large Cars | 3535 | 68.1 | 3652 | 68.2 |

Source: Highway Loss Data Institute, Cars by Make and Model, September 1987.

CHAPTER SIX

# Regulation of Fuel Economy

GOVERNMENT regulation of fuel economy takes two forms—the corporate average fuel economy standards (CAFE) and the "gas guzzler" tax. At the time both policies were enacted, the government was simultaneously encouraging gasoline consumption by imposing maximum price regulation on crude oil and refined products. This counterproductive strategy has since been abandoned as oil and gasoline prices have been allowed to reach market-clearing levels.

When safety regulation began in 1966, there were no other exogenous changes (with the possible exception of increased product liability exposure) that would have induced automobile producers to increase the safety of their vehicles dramatically. Indeed, we have argued that the improvement in vehicle safety must be attributed in large part to government regulation. Similarly, one would not have expected the dramatic reduction in vehicle emissions that has occurred since 1968 if there had been no government regulation of emissions.

In the case of fuel economy, however, the Arab oil embargo and the subsequent rise in the real price of motor fuel would surely have induced a response from the automobile companies and consumers in the absence of fuel economy regulation. Automobiles would be much more fuel efficient today even if the government had not chosen to regulate fuel efficiency. In fact, it is by no means clear that the CAFE standards imposed a binding constraint on automobile producers until real gasoline prices began falling in 1981. As we shall see, however, it is not easy to sort out the effects of regulation from those of the rise in gasoline prices.

## Automobile Design and Fuel Economy

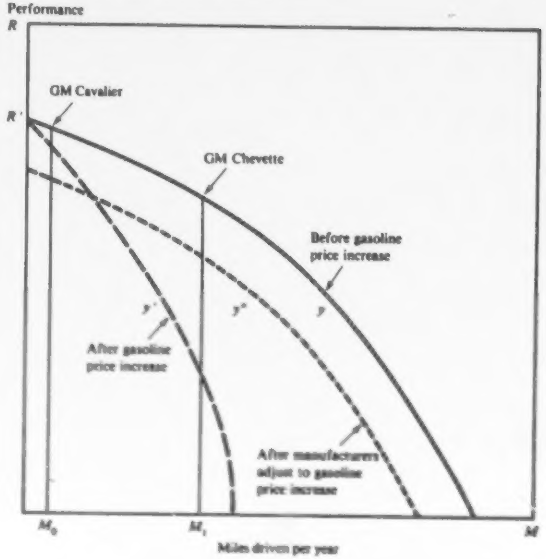
The diversity of consumer tastes and the proliferation of automobile designs to address these tastes always complicate attempts to model the automobile industry's product offerings. There are some people who want heavy "road cruisers" while others desire sports cars with superior handling. Others simply opt for basic transportation. In each case, however, one may assume that rational consumers will pay for added fuel efficiency up to the point where the added cost of delivering fuel efficiency just equals the present value of gasoline saved.[1] Otherwise, one could not explain the penchant for diesel engines among U.S. owners of Mercedes (particularly in northern climates).[2]

Automobile manufacturers offer an array of vehicles with different efficiency-performance characteristics to appeal to various groups of consumers. In chapter 3, we provided a model of the response of manufacturers to changing regulatory demands, factor prices (including fuel), and tastes. In this chapter, we explore the reaction of the domestic automobile companies to higher fuel prices and government regulation of fuel economy.

Time plays a very important role in adjusting automobile purchases to changes in relative operating costs. A sudden increase in gasoline costs causes consumers to adjust their use of cars already on the road and their purchases of new automobiles. At first, the choice of new cars is from those models in current production, whose design reflects manufacturers' expectations as much as four or five years ago. For instance, a consumer choosing to allocate $y$ dollars in annual expenditures on automobile travel may have the choice between performance—acceleration, ride, handling, and interior comfort—and annual mileage as shown by the convex line, $y$, in figure 6-1. If he wants to drive $M_1$ miles per year, at current gasoline prices, the best performance available is that of, say, a Chevette. If he chooses to buy a car and operate it only $M_0$ miles per year, he can buy a GM Cavalier—a car with better performance.

What if gasoline prices suddenly rise? The consumer's opportunities rotate around $R'$ downward along $y'$. At each mileage, the consumer can afford less performance because of higher gasoline prices. But the locus, $y'$, reflects automobile choices from a selection of models brought to the market by manufacturers when gasoline prices were lower. In time, manufacturers will reduce performance levels or improve engineering or both in an effort to improve fuel economy. As a result, the consumer's eventual choices will be made along $y''$ for $y$ dollars in annual outlays. This opportunity set will be inside the original locus, $y$, because at all performance levels the cost per mile of driving is higher with the new models than with the older models and lower gasoline prices.

Figure 6-1. Trade-offs between Performance and Annual Vehicle Miles Traveled, before and after a Major Increase in Gasoline Prices



After new models begin to appear, reflecting the improved fuel efficiency at each performance level, consumers begin to readjust their purchases toward higher-performance (and perhaps larger) cars. In addition, these more efficient cars permit greater annual mileage accumulation. This result is shown in figure 6-2, where a hypothetical consumer is shown to find his optimum at the tangency of an indifference (constant satisfaction)

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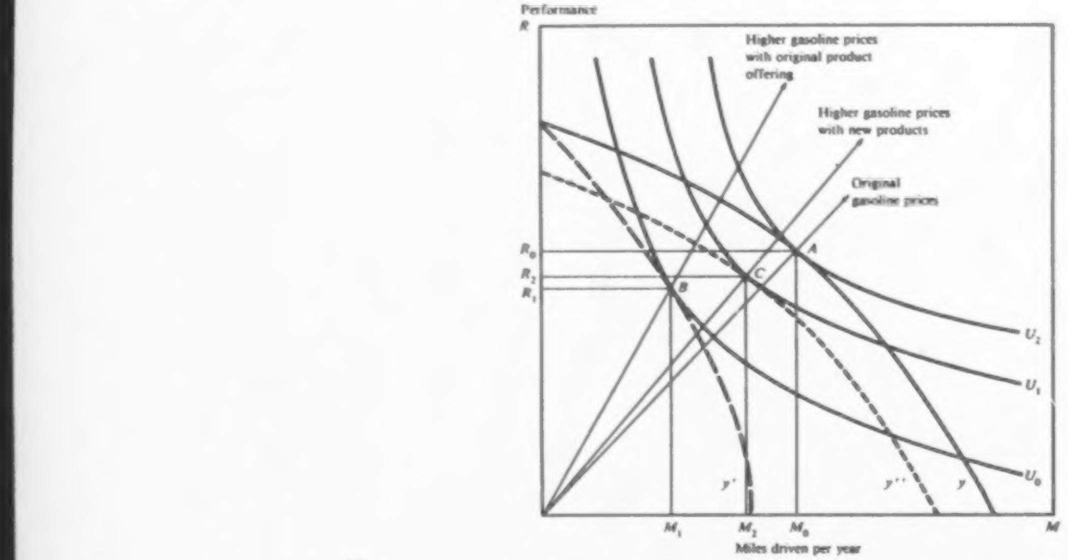
[1] Roger Blair, David Kaserman, and Richard Tepel, "The Impact of Improved Mileage on Gasoline Consumption," *Economic Inquiry*, vol. 22 (April 1984), pp. 209–17.

[2] Carl Nash reminds us that Mercedes need diesels to meet CAFE standards, but diesels antedate CAFE.

Figure 6-2. The Response to Higher Gasoline Prices



curve and the *y* opportunity locus—a point labeled *A*. When gasoline prices rise, his choice is changed temporarily to *B*, since he reduces both mileage and performance substantially when confronted with the same old choice of vehicles, reducing his satisfaction level from $U_2$ to $U_0$. When automobile producers adjust to the new gasoline prices, our hypothetical consumer would move to *C*, reflecting a choice of performance and mileage between *A* and *B*. His satisfaction level would be increased to $U_1$. When offered a more fuel-efficient set of vehicles, consumers move back toward their original equilibrium. This explains why one frequently hears the lament that automobile buyers are "returning" to the large cars, forgetting the "lessons" learned from a recent gasoline price shock.

## The Fuel Economy Standards

Congress imposed corporate average fuel economy standards (CAFE) on automobile manufacturers in 1975. These standards set the harmonic-weighted fleet average for manufacturers, based upon EPA city-highway ratings, at 18 miles per gallon by the 1978 model year and 27.5 miles per gallon by the 1985 model year.[3] The Department of Transportation was empowered to set interim standards for 1981–84. Fines are imposed on a manufacturer failing to make the CAFE standard, but those who exceed the standards in previous or future years are allowed carryovers and carrybacks. These carryovers and carrybacks were extended from one to three model years by 1980 legislation.[4] In addition, gas guzzler taxes—manufacturers' excise taxes—are added to each car that fails to achieve a given fuel economy.[5]

According to EPA data, the fleet-average fuel efficiency of U.S. cars has nearly doubled over 1973–84 (table 6-1); however, much of this improvement would surely have occurred without regulation.[6] The sharp increase in the price of gasoline and declining real income growth would have led consumers to be much more cognizant of fuel efficiency. On the other hand, the erratic pace of real gasoline price increases may have slowed progress somewhat. For instance, the real CPI motor fuel index jumped by 22 percent in 1974 (table 6-1) but then receded by 7 percent in the next four years, in part because of federal price regulation. Between 1978 and 1981, it rose sharply once again—by 50 percent over this three-year period. Since 1981 gasoline prices have eased substantially, and the

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[3] Energy Policy and Conservation Act of 1975 (89 Stat. 902). This act amended the Motor Vehicle Information and Cost Savings Act (86 Stat. 947). The CAFE standard is a harmonic-weighted fleet average rather than an arithmetic average because the total mileage amassed by an individual manufacturer's model-year sales is $\Sigma M_i Q_i$ where $M_i$ is the annual mileage accumulated by the *i*th model and $Q_i$ is the number of *i*th models sold; the total gallons consumed by these cars is equal to $\Sigma(M_i Q_i / E_i)$, where $E_i$ is the mpg rating of the *i*th model; and, assuming that all $M_i$ are equal, the mpg for the manufacturer's total fleet is equal to $\Sigma Q_i / \Sigma(Q_i / E_i)$.

[4] Automobile Fuel Efficiency Act of 1980 (94 Stat. 1821).

[5] See Internal Revenue Code sec. 1016(d). The tax is set at $5 per 1/10 of a mile per gallon below the CAFE standard, per car.

[6] For a discussion of fuel economy measures, see Karl H. Mellman and J. Dillard Murrell, "Why Vehicles Don't Achieve the EPA MPG on the Road and How That Shortfall Can Be Accounted For," Society of Automotive Engineers Technical Paper 820791 (Warrendale, Pa.: SAE, 1982).

Table 6-1. Estimates of Fuel Economy, Model Years 1968–84

| | *Mileage (miles per gallon)* | | | *Real price of motor fuel* |
|---|---|---|---|---|
| *Year* | *City* | *Highway* | *Harmonic average*[a] | *(1967 = 100)*[b] |
| 1968 | 12.59 | 18.42 | 14.69 | 97.3 |
| 1969 | 12.60 | 18.62 | 14.74 | 95.4 |
| 1970 | 12.59 | 19.01 | 14.85 | 90.8 |
| 1971 | 12.27 | 18.18 | 14.37 | 87.6 |
| 1972 | 12.15 | 18.90 | 14.48 | 85.9 |
| 1973 | 12.01 | 18.07 | 14.15 | 88.7 |
| 1974 | 12.03 | 18.23 | 14.21 | 108.3 |
| 1975 | 13.68 | 19.45 | 15.79 | 106.0 |
| 1976 | 15.23 | 21.27 | 17.46 | 104.3 |
| 1977 | 15.99 | 22.26 | 18.31 | 103.7 |
| 1978 | 17.24 | 24.48 | 19.89 | 100.5 |
| 1979 | 17.70 | 24.60 | 20.25 | 122.2 |
| 1980 | 20.35 | 29.02 | 23.51 | 149.6 |
| 1981 | 21.75 | 31.12 | 25.16 | 150.8 |
| 1982 | 22.32 | 32.76 | 26.06 | 134.7 |
| 1983[c] | 22.21 | 32.90 | 26.01 | 126.1 |
| 1984[c] | 22.67 | 33.69 | 26.59 | 119.2 |

Sources: R. M. Heavenrich and others, "Passenger Car Fuel Economy . . . Trends thru 1984," Environmental Protection Agency Paper 840499 (EPA, 1984), p. 4; and *Economic Report of the President, February 1985*, pp. 291, 293.

a. Based on 55 percent city driving and 45 percent highway driving.
b. Consumer price index for motor fuel divided by total CPI.
c. Based on estimated sales weights supplied by the manufacturers.

real price of motor fuel in 1984 was 21 percent lower than in 1981. Given this erratic behavior of fuel prices, it is possible that the CAFE regulations accelerated the adjustment to more fuel-efficient cars. Automobile manufacturers typically require long lead times to respond to changing technologies or consumer tastes. The CAFE standards may have forced a more rapid adjustment.

### *Manufacturers' Responses*

The first CAFE standards applied to 1978 model cars that were introduced less than three years after the passage of the Energy Policy and Conservation Act in 1975. In this short period, automobile manufacturers could not have been expected to have completed their response to the required standards (if binding) or to the 1973–74 gasoline price increases. Designing, engineering, and producing a new automobile can require four

years or more.[7] Adjusting a major manufacturer's entire product offering may require a decade or more.

General Motors provides a good example of the difficulties of adjusting an entire product offering to the new demand for fuel efficiency. In response to the sharp increase in the demand for small cars, GM introduced the Chevette in 1975. This was hardly a major product change since the Chevette was largely an amalgam of design features drawn from European cars. In the 1977 model year, GM introduced its first downsized standard cars, and the company downsized its intermediate cars in the 1978 model year. In 1979 the X-body was introduced, representing the first major design change by GM since the 1973–74 oil shock. The new front-wheel-drive J-body cars were introduced in 1981 to compete with the more expensive fuel-efficient imports from Japan. The J cars also represented a major design change, although at first they utilized a disappointing version of an existing GM engine. In 1982 GM introduced a new series of front-wheel-drive A-body cars—intermediate Chevrolets, Buicks, Pontiacs, and Oldsmobiles. The company downsized some of the larger cars in its fleet in 1984, but even by then it had not fully readjusted its fleet to 1984 gasoline prices, competitive offerings from imports and its domestic competitors, and the changes in consumer tastes.[8]

General Motors was preparing to reduce the weight of its cars two years before the Arab oil embargo.[9] This meant that product development decisions were being reexamined as early as 1971, but none of these decisions could have affected product offerings before 1974. In 1970–72 the model lines offered by the major U.S. producers were clearly designed for low gasoline prices. By 1975, fuel prices were substantially higher, but major changes in vehicle design or engines could not have been expected before 1977 or 1978. The Energy Policy and Conservation Act was also passed in 1975, mandating CAFE standards for 1978 through 1985. Any effects of this new set of government regulations on automobile design might have begun to appear by the 1978 model year, but the major impact would have been in evidence no earlier than the 1979 or 1980 model years.

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[7] See Energy and Environmental Analysis, *The Technology/Cost Segment Model for Post-1985 Automotive Fuel-Economy Analysis*, prepared for the Department of Energy (Arlington, Va.: Energy and Environmental Analysis, 1981), chap. 3.

[8] GM's decisions to build subcompact cars in a joint venture with Toyota and to undertake a major new subcompact program (the Saturn) are evidence of a continuing attempt to adjust its product mix to the new realities of the market.

[9] See John Z. DeLorean and J. Patrick Wright, *On a Clear Day You Can See General Motors: John Z. DeLorean's Look inside the Automotive Giant* (Avon Books, 1979), pp. 215–17, for John DeLorean's discussion of the proposal to downsize GM cars.

To see how the vehicle manufacturers responded to changing fuel prices and CAFE standards, one might begin with a simple listing of the attributes of three different size classes of automobiles—full-size, low-price sedans; intermediate sedans; and subcompacts. The fuel economy, acceleration from 0 to 60 miles per hour, and weight of each of the Big Three's representative product offerings for various years in the 1970s are exhibited in table 6-2. To increase fuel economy, the manufacturers could reduce weight, reduce engine power, or improve the technology of existing engine-weight combinations. Clearly, all three major manufacturers chose to reduce both weight and acceleration in response to the increase in energy prices.

There was only marginal improvement in fuel economy through 1975–76, much of it obtained by sacrificing acceleration. In addition, emissions controls were exacting a fuel penalty during these years. Between 1975 and 1979, all three assemblers reduced the weight of their full-sized models by nearly 15 percent. The resulting fuel economy was about 15 percent above 1975 levels for the generally smaller V-8s reported in *Consumer Reports*. In the case of intermediate cars, Ford and General Motors increased fuel economy by reducing weight sharply between 1975 and 1978 without sacrificing acceleration. Only Chrysler failed to downsize its intermediate offerings, but it managed a 12 percent improvement in fuel economy between 1971 and 1978 with little loss in acceleration and even an increase in weight. The subcompact cars showed only minor improvements in fuel economy between 1971 and 1976. (Chrysler had no domestic car in this category.) Ford improved the performance and fuel economy of its Pinto while adding weight to it in 1971–76, but GM clearly sacrificed acceleration to gain fuel economy with its Chevette.

The foregoing analysis suggests that the major vehicle producers in the United States began to improve fuel economy in a minor way by 1975, but that the major improvement occurred with the reductions in vehicle weight in 1977–78, three years after the Arab oil embargo. This is somewhat less than the product-development lead time generally required by Detroit in recent years. Therefore it appears that the major changes in product offerings before the development of front-wheel-drive cars were driven by the sharp rise in fuel prices in 1973–74 and not by the enactment of the CAFE program in 1975.

**Table 6-2. Weight, Acceleration, and Fuel Economy for New Passenger Cars, Selected Model Years, 1971–79**

| *Year and automobile* | *Curb weight (pounds)* | *Acceleration from 0–60 (seconds)* | *Mileage (miles per gallon)*[a] |
|---|---|---|---|
| *Full-size, low-price sedans (V-8)* | | | |
| General Motors | | | |
| 1971 (Chevrolet Impala) | 4,209 | 12.0 | 14.0 |
| 1975 (Chevrolet BelAir) | 4,440 | 14.0 | 15.0 |
| 1979 (Chevrolet Caprice Classic) | 3,840 | 15.4 | 17.0 |
| Ford | | | |
| 1971 (Galaxie 500) | 4,154 | 13.5 | 14.0 |
| 1975 (LTD) | 4,657 | 13.5 | 14.0 |
| 1979 (LTD) | 3,725 | 13.4 | 17.6 |
| Chrysler | | | |
| 1971 (Plymouth Fury III) | 4,096 | 13.0 | 14.0 |
| 1975 (Plymouth Fury) | 4,498 | 14.5 | 16.0 |
| 1979 (Dodge St. Regis) | 3,830 | 15.2 | 18.2 |
| *Intermediate sedans (six cylinders)* | | | |
| General Motors | | | |
| 1971 (Chevelle) | 3,329 | 15.5 | 17.0 |
| 1975 (Chevelle) | 3 897 | 18.5 | 16.0 |
| 1978 (Chevrolet Malibu) | 3,155 | 18.2 | 20.5 |
| Ford | | | |
| 1971 (Torino) | 3,302 | 16.5 | 19.0 |
| 1975 (Mercury Monarch) | 3,432 | 21.0 | 15.0 |
| 1978 (Fairmont) | 2,965 | 15.8 | 20.2 |
| Chrysler | | | |
| 1971 (Dodge Dart) | 3,048 | 17.0 | 18.0 |
| 1975 (Plymouth Valiant) | 3,264 | 16.0 | 19.0 |
| 1978 (Plymouth Volare) | 3,430 | 17.2 | 20.5 |
| *Subcompact two-door (four cylinders)* | | | |
| General Motors | | | |
| 1971 (Chevrolet Vega) | 2,264 | 15.5 | 28.0 |
| 1976 (Chevette) | 2,035 | 22.2 | 29 0 |
| Ford | | | |
| 1971 (Pinto) | 2,046 | 19.0 | 25.0 |
| 1976 (Pinto Pony) | 2,565 | 13.6 | 26.5 |

Source: *Consumer Reports*, various issues.
a. Average trip.

## *Compliance with CAFE, 1978–85*

The three major U.S. producers have very different records of conformance to CAFE standards. In 1978 all three were safely over the standard, but falling real gasoline prices found Ford and GM very close to the

**Table 6-3. The Big Three's Compliance with Corporate Average Fuel Economy Standards for Cars Produced in the United States, Model Years 1978–85[a]**
Miles per gallon

| *Year* | *Standard* | *General Motors* | *Ford* | *Chrysler* |
|---|---|---|---|---|
| 1978 | 18.0 | 19.0 | 18.4 | 18.4 |
| 1979 | 19.0 | 19.1 | 19.1 | 20.4 |
| 1980 | 20.0 | 22.4 | 22.6 | 22.1 |
| 1981 | 22.0 | 23.7 | 23.9 | 26.7 |
| 1982 | 24.0 | 24.6 | 25.0 | 27.6 |
| 1983 | 26.0 | 24.0 | 24.3 | 27.0 |
| 1984 | 27.0 | 24.9 | 25.3 | 27.1 |
| 1985 | 27.5 | 25.1[b] | 25.9[b] | n.a. |

Sources: National Highway Traffic Safety Administration, *Annual Fuel Economy Program*, various years; General counsel, U.S. Department of Commerce, to NHTSA, "Comments Concerning . . . Petitions by GM and Ford," April 30, 1985; and "EPA Grants Automakers Fuel Economy Credits to Compensate for Test Changes," *EPA News*, June 26, 1985.

n.a. Not available.

a. Based on 55 percent city driving and 45 percent highway driving. Manufacturers' estimates for 1980–84 reflect revisions by the EPA in 1985.

b. Predicted by the companies.

standard in the 1979 model year. The Iranian revolution led to a sharp increase in fuel prices and a resultant shift toward smaller cars in 1979–80, thereby raising the mpg ratings for all three manufacturers to more than 22. Beginning in 1981, however, Chrysler, with its small cars, began to exceed the CAFE standard by a substantial margin (table 6-3) while GM and Ford remained rather close to it. In 1983, as gasoline prices fell, the demand for the larger cars produced by GM and Ford began to rise sharply, and these two companies found themselves falling below the standard for the first time. This was not a problem in 1983 because both had substantial carryover credits from 1980 that would have expired at the end of the model year. By 1985, however, both companies admitted that their current model offerings and prices would put them so far below the standard that they would exhaust their previous carryforward credits and begin paying fines for noncompliance for the first time.[10] Chrysler, on the other hand, remained safely above the CAFE standard and was arguing for continuing the program without easing the standards. In October 1985, however, the Department of Transportation announced a reduction in the standard to 26 mpg for the 1986 model year.[11]

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[10] *Automotive News*, January 7, 1985, p. 1.

[11] 50 Fed. Reg. 40528 (1985).

## A Test of the Effect of Standards upon Fuel Economy

To estimate the temporal pattern of changes in fuel economy and the impact of CAFE standards, a more precise analysis is required. Since fuel economy should be a function of engine size, the weight moved by this engine, and the design of the car, the following relationship suggests itself:

$$(1) \qquad MPG = f\,(DISP,\ WT,\ FWD),$$

where *MPG* is the miles per gallon for a specified driving mode, *DISP* is the interior volume of the engine in cubic inches, *WT* is curb weight, and *FWD* is a dummy variable for the new front-wheel vehicle designs. Equation 1 is estimated in loglinear form since the effect of weight and engine size should be multiplicative. Dummy variables are added for three of the four manufacturers to capture firm-specific differences (AMC is omitted). In addition, time dummies are included to capture the effect of other influences, such as technological change and regulation. The equation estimated is

$$\begin{aligned}(2) \qquad \log MPG_i &= a_0 + a_1 \log WT_i + a_2 \log DISP_i \\ &+ a_3 FWD_i + a_4 D71_i + \ldots + a_{17} D84_i \\ &+ a_{18} GM_i + a_{19} FORD_i + a_{20} CHRYS_i + u_i.\end{aligned}$$

To estimate equation 2, observations are drawn from all domestic U.S. sedans tested by Consumers Union during 1970–84. In all, 186 models qualify, reflecting a satisfactory mix of all size classes. This data base is especially useful because it provides estimates of fuel economy from actual road tests. The fuel economy estimates are reported for city and highway driving and for a specified test trip. Unfortunately, the nature of the test trip used by Consumers Union and the maximum speeds during such a trip have changed over the 1970–84 period. For this reason, we estimate equation 2 for mileage reported for city driving, for highway driving, and for a harmonic average (55 percent city, 45 percent highway) of the two as well as for the test trip. These estimates appear in table 6-4.

In each case, the estimated effect of weight on fuel economy is very large and statistically significant. *DISP* is also inversely correlated with fuel economy, as expected. Chrysler and General Motors appear to obtain

Table 6-4. Determinants of Fuel Economy as Measured by Mileage under Selected Conditions [a]

| *Independent variable* | *Measured trip* | *City* | *Highway* | *Harmonic average* [b] |
|---|---|---|---|---|
| Constant | 8.71* | 9.72* | 8.05* | 9.28* |
|  | (17.09) | (19.18) | (14.73) | (20.09) |
| Log *WT* | −0.63* | −0.83* | −0.51* | −0.73* |
|  | (6.42) | (8.52) | (4.92) | (8.31) |
| Log *DISP* | −0.14* | −0.12* | −0.15* | −0.13* |
|  | (2.53) | (2.24) | (2.60) | (2.64) |
| *FWD* | 0.08* | 0.02 | 0.07* | 0.03 |
|  | (3.39) | (0.72) | (2.87) | (1.55) |
| Chrysler | 0.02 | 0.03 | 0.03 | 0.03 |
|  | (1.02) | (1.21) | (1.18) | (1.36) |
| Ford | 0.01 | −0.01 | −0.01 | −0.01 |
|  | (0.55) | (0.41) | (0.30) | (0.42) |
| General Motors | 0.03 | −0.01 | 0.04* | 0.01 |
|  | (1.44) | (0.35) | (2.00) | (0.40) |
| *Time dummies* |  |  |  |  |
| *D71* | −0.03 | −0.01 | −0.02 | −0.02 |
|  | (1.10) | (0.47) | (0.65) | (0.62) |
| *D72* | −0.10* | −0.01 | −0.05 | −0.02 |
|  | (2.78) | (0.16) | (1.36) | (0.61) |
| *D73* | −0.12* | 0.01 | −0.06* | −0.01 |
|  | (4.06) | (0.42) | (2.06) | (0.38) |
| *D74* | 0.01 | −0.01 | −0.01 | −0.01 |
|  | (0.20) | (0.33) | (0.26) | (0.32) |
| *D75* | 0.01 | 0.06 | −0.05 | 0.02 |
|  | (0.28) | (1.74) | (1.52) | (0.81) |
| *D76* | 0.10* | 0.16* | 0.04 | 0.12* |
|  | (3.14) | (4.77) | (1.05) | (4.04) |
| *D77* | 0.08* | 0.15* | 0.04 | 0.12* |
|  | (2.19) | (4.19) | (1.02) | (3.60) |
| *D78* | 0.11* | 0.13* | 0.09* | 0.12* |
|  | (3.04) | (3.69) | (2.41) | (3.72) |
| *D79* | 0.14* | 0.14* | 0.12* | 0.13* |
|  | (4.02) | (4.13) | (3.26) | (4.35) |
| *D80* | 0.17* | 0.11* | 0.16* | 0.13* |
|  | (3.71) | (2.55) | (3.30) | (3.12) |
| *D81* | 0.10* | 0.18* | 0.13* | 0.17* |
|  | (2.39) | (4.52) | (2.94) | (4.52) |
| *D82* | 0.15* | 0.18* | 0.19* | 0.18* |
|  | (3.63) | (4.53) | (4.50) | (5.08) |
| *D83* | 0.20* | 0.27* | 0.28* | 0.27* |
|  | (5.52) | (7.38) | (7.24) | (8.23) |
| *D84* | 0.12* | 0.22* | 0.19* | 0.21* |
|  | (2.87) | (5.44) | (4.36) | (5.74) |
| *Summary statistic* |  |  |  |  |
| $\bar{R}^2$ | 0.919 | 0.926 | 0.902 | 0.934 |

* Statistically significant at the 95 percent confidence level.

[a] Dependent variable is logarithm of *MPG*. Numbers in parentheses are *t*-statistics.

[b] Based on 55 percent city driving and 45 percent highway driving.

better fuel economy than Ford or AMC, other things being equal. Finally, the front-wheel-drive sedans appear to get between 2 and 8 percent better fuel economy than their rear-wheel-drive counterparts. This may be due to a number of design changes, including the shape of the outer body, facilitated by a complete redesign of the vehicle.

For our purposes, we are particularly interested in the coefficients of the time dummies, for these estimates give us an estimate of the technological improvement in vehicle design, not just the reduction in weight and horsepower. These suggest no fuel economy improvements until 1975 or 1976, but steady improvement thereafter. There is some sign of a flattening of this improvement in 1980–81, but a resumed increase in fuel economy in 1983. Before drawing any conclusions from these coefficients, however, we must attempt to correct for the penalties incurred because of emissions regulation in order to obtain estimates of temporal improvement in fuel economy generated by design changes. For this purpose, we use White's estimates of the emissions control penalties in each year. These are added to the harmonic averages of city and highway mileage of the time dummies from table 6-4 (see table 6-5). For instance, the fuel economy penalty of 8 percent in 1973 and 1974 is added to the coefficients of *D73* and *D74*, each of which is −0.01, to obtain an estimated "total" increase of 7 percent over 1970 fuel economy for both years. By 1977 it appears that cars were 15 percent more fuel efficient, holding weight, engine size, and emissions control constant. By 1981 this had risen to 24 percent above 1970 levels, and by 1983 the improvement was 34 percent.

The estimated progress in fuel economy reflected in table 6-5 has one sharp discontinuity in 1975, the year in which the major assemblers shifted to the catalyst technology for controlling emissions. One would expect the coefficient of *D75* in table 6-4 to be substantially larger than the coefficient of *D74*, but this obviously is not the case. It is possible that some manufacturers had difficulty in adjusting to the new technology. General Motors developed it and might be expected to have had better experience with it. To test for significant differences between GM and the other companies, we reestimate equation 2 for each of the three major firms in the industry. As the results in table 6-6 clearly indicate, GM's progress in fuel economy was much steadier than that of its rivals. In the watershed year of 1975, it realized a 6 percent improvement—very close to White's estimate of the reduction in the emissions control penalty—while the other firms showed no significant improvement. Moreover, GM evidenced an improvement of approximately 45 percent from 1970 through 1983 while Ford showed an improvement of 37 percent and Chrysler may have

**Table 6-5. Fuel Economy Improvement over 1970 Model Cars, Model Years 1971–84**
Percent

| Year | Estimated improvement[a] | Estimated emissions control penalty[b] | Total improvement |
|---|---|---|---|
| 1971 | −2 | 0 | −2 |
| 1972 | −2 | 0 | −2 |
| 1973 | −1 | 8 | 7 |
| 1974 | −1 | 8 | 7 |
| 1975 | 2 | 1 | 3 |
| 1976 | 12 | 1 | 13 |
| 1977 | 12 | 3 | 15 |
| 1978 | 12 | 3 | 15 |
| 1979 | 13 | 3 | 16 |
| 1980 | 13 | 6 | 19 |
| 1981 | 17 | 7 | 24 |
| 1982 | 18 | 7 | 25 |
| 1983 | 27 | 7 | 34 |
| 1984 | 21 | 7 | 28 |

a. From table 6-4.
b. Estimates by Lawrence J. White, *The Regulation of Air Pollutant Emissions from Motor Vehicles* (Washington, D.C.: American Enterprise Institute, 1982), p. 21.

improved its fuel economy by perhaps 11 percent, after adjusting for the fuel penalty from emissions control. Surprisingly, front-wheel drive seems to do little for fuel economy for any of the firms. Given the difficulties GM has had with reliability and performance of its early front-wheel-drive cars, it may be wondering if the transformation of its fleet has been worthwhile.

The surprising result from this analysis is that the companies responded to the demand for fuel efficiency at quite different rates. General Motors showed substantial improvement in efficiency by 1974. This is consistent with reported observations that GM had begun to develop more fuel-efficient cars two years before the 1973 oil shock. Ford, on the other hand, evidenced substantial progress in its 1976 and 1983 models—two years after the first oil shock and four years after the second. Finally, Chrysler seemed to make little progress until about 1979, when the second oil shock was occurring. Apparently, Chrysler simply relied upon the strategy of eliminating its large cars, making itself vulnerable to the small car competition from Japan that began in earnest in the late 1970s.

Despite its difficulties with the CAFE standards since 1982, it is clear that GM has made the greatest progress in improving fuel efficiency since 1970, given the weight of its cars. Its progress has been more than double

**Table 6-6. Determinants of Fuel Economy for General Motors, Ford, and Chrysler Cars, Model Years 1970–84[a]**

| Independent variable | General Motors (N = 72) | Ford (N = 47) | Chrysler (N = 42) |
|---|---|---|---|
| Constant | 10.07* | 9.14* | 9.16* |
| | (12.38) | (9.39) | (6.97) |
| Log *WT* | −0.91* | −0.74* | −0.62* |
| | (5.64) | (3.99) | (2.51) |
| Log *DISP* | −0.02 | −0.09 | −0.26 |
| | (0.23) | (0.92) | (1.85) |
| *FWD* | 0.02 | 0.04 | 0.07 |
| | (0.60) | (0.70) | (1.11) |
| *Time dummies* | | | |
| *D71* | 0.02 | 0.01 | −0.12 |
| | (0.47) | (0.20) | (1.88) |
| *D72* | 0.00 | −0.06 | 0.02 |
| | (0.08) | (0.82) | (0.28) |
| *D73* | 0.01 | −0.08 | −0.01 |
| | (0.30) | (1.29) | (0.23) |
| *D74* | 0.08 | −0.04 | −0.03 |
| | (1.51) | (0.61) | (0.38) |
| *D75* | 0.14* | −0.08 | −0.04 |
| | (2.74) | (1.20) | (0.58) |
| *D76* | 0.20* | 0.12 | 0.06 |
| | (3.89) | (1.90) | (0.93) |
| *D77* | 0.18* | 0.12 | 0.01 |
| | (3.66) | (1.56) | (0.15) |
| *D78* | 0.20* | 0.07 | 0.03 |
| | (3.91) | (0.90) | (0.55) |
| *D79* | 0.20* | 0.09 | 0.09 |
| | (4.17) | (1.35) | (1.40) |
| *D80* | 0.22* | 0.08 | −0.07 |
| | (3.80) | (0.77) | (0.79) |
| *D81* | 0.29* | 0.15 | 0.00 |
| | (5.26) | (1.83) | (0.02) |
| *D82* | 0.30* | 0.14* | 0.07 |
| | (4.69) | (2.00) | (0.97) |
| *D83* | 0.38* | 0.30* | 0.04 |
| | (7.61) | (4.36) | (0.59) |
| *D84* | 0.27* | 0.25* | 0.00 |
| | (4.89) | (3.40) | (0.01) |
| *Summary statistic* | | | |
| $\bar{R}^2$ | 0.956 | 0.925 | 0.950 |

* Statistically significant at the 95 percent confidence level.
a. Dependent variable is logarithm of harmonic average of city and highway driving. Numbers in parentheses are *t*-statistics.

Chrysler's even though Chrysler has had greater success in meeting the CAFE standards. The explanation for this apparent anomaly, of course, is that Chrysler has virtually abandoned large cars while GM continues to produce very successful big cars.

A further statistical analysis shows that the average annual rate of progress for GM in increasing fuel economy for vehicles of a given weight and engine displacement was approximately 3 percent through 1983. Ford's trend rate of improvement was 2 percent and Chrysler's a bare 1 percent. In 1970–73, before the oil crisis, Chrysler's automobiles were approximately 6 percent more fuel efficient than those of Ford and 8 percent more fuel efficient than those of GM, holding weight and displacement constant. Thus it would appear that by 1983 GM cars were substantially more fuel efficient than Chrysler cars and marginally more fuel efficient than Ford cars for a given weight and displacement.

## A Test of Fuel Economy without Standards

All three major domestic assemblers improved the fuel economy of their vehicles in 1970–83, with most of the improvement coming after 1975. Nevertheless, Ford and GM had made substantial progress by 1976—before the prospective requirements of the Energy Policy Conservation Act of 1975 could have been anticipated. This fact alone suggests that the market price of gasoline and the growing competition from imports was impelling the assemblers along a path of improving fuel economy.

Had there been no CAFE standards, the vehicle producers could have been expected to increase fuel economy as long as the gain in operating costs of a car was at least as great as the increase in the costs of producing and distributing the car. Improving aerodynamic design and drive trains and even substituting low-weight materials for iron and steel require increases in costs. The cost-minimizing choice of fuel efficiency ($E$) and vehicle price ($P$) is easily stated as[12]

$$c = \frac{p_g M/E}{rP}, \tag{3}$$

where $c$ is the elasticity of the cost of producing a vehicle with respect to fuel efficiency, $p_g$ is the price of gasoline, $M$ is annual vehicle miles traveled by the consumer, and $r$ is the cost of capital to the consumer for holding a durable good such as an automobile.

Equation 3 simply states that vehicle manufacturers should offer fuel economy on each model line up to the point where the elasticity of the cost of production with respect to fuel economy is equal to the ratio of annual gasoline costs to the annual capital costs of holding the car. Unfortunately, we have no data on production costs from which to estimate $c$ directly, but we can proceed along a somewhat less elegant route.

First, it is possible to assemble data on the cost of operating and holding a new automobile. According to estimates published by the Department of Transportation, the ratio of the present value of gasoline costs to that of capital costs for a car held for four years was 0.31 for 1972 model automobiles and 0.42 for 1981 model cars.[13] The 1981 figure reflects the sharp rise in gasoline prices in 1979–81 after the fall of the Shah of Iran. Further improvements in fuel economy and lower gasoline prices in 1982–84 would surely lower this ratio. A reasonable approach would be to average the 1972 and 1981 estimates and suggest that the implicit estimate of $c$, the elasticity of costs with respect to fuel economy, is about 0.365.

Further corroboration of this estimate may be found in a 1980 Congressional Budget Office study that analyzed potential fuel efficiency improvements over 1985–95.[14] This study estimated that potential improvements

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[12] This follows from the assumption of rational consumer choice in fuel price-efficiency trade-offs. If vehicle manufacturers can obtain higher fuel efficiency through additional engineering expense and if these costs are passed on to buyers, the manufacturers should increase fuel economy until the additional cost of holding a car for a year is just equal to the annual savings in gasoline costs: $\partial[P_g M/E]/\partial E$. This simplifies into equation 3.

[13] Authors' calculations based on Department of Transportation, Federal Highway Administration, *Cost of Operating an Automobile* (DOT, 1972), and *The Cost of Owning and Operating Automobiles and Vans* (DOT, 1982).

[14] Congressional Budget Office, *Fuel Economy Standards for New Passenger Cars after 1985* (Government Printing Office, 1980), pp. 30–31, 38. Earlier estimates of the costs of achieving 1978–85 standards vary considerably. *The Final Impact Assessment of the Automotive Fuel Economy Standards for Model Year 1981–84 Passenger Cars*, prepared by the National Highway Traffic Safety Administration in 1977, estimated the total unit cost of raising mpg from 20 to 27 at $195 per car. The average cost per car in 1977 was $4,788, based upon a Bureau of Economic Analysis estimate of an average 1977 transaction price of $5,985 and a 25 percent markup. Therefore the elasticity of fuel economy with respect to cost would be 0.116 from these data. This estimate is very low because most of the prospective improvements derive from downsizing and diesel engines.

A more recent study by Energy and Environmental Analysis, *The Technology/Cost Segment Model*, estimates a 40 percent improvement in fuel economy from eleven technoin fuel economy of 26.9 percent would cost $562 per new vehicle (in 1980 dollars). Given an average new car price of $7,578 in 1980, this translates into a 7.4 percent increase in car prices to obtain a 26.9 percent savings in fuel. The implicit value of $c$ from this exercise would be 0.28. A more pessimistic CBO scenario sees a 17.6 percent fuel economy improvement for $624 in increased new car prices, or an implicit value of $c$ equal to 0.47. The midpoint of these estimates is very close to our estimate of 0.365.

If the estimated elasticity of the price of a new automobile with respect to fuel economy is about 0.36, the effect of increased gasoline prices upon the engineering of fuel efficiency may be deduced quite simply. We know that in equilibrium manufacturers will satisfy equation 3. The differential of this expression (assuming constant $M$) is

$$dc = \frac{-p_g M}{rPE^2}\, dE + \frac{M}{rPE}\, dp_g - \frac{p_g M}{rP^2E}\, dP - \frac{p_g M}{r^2PE}\, dr. \tag{4}$$

If the elasticity is constant in the relevant range of costs, $dc = 0$ for all changes in fuel prices or other variables. Equation 4 may therefore be rewritten and simplified into

$$dp_g/p_g = dE/E + dP/P + dr/r. \tag{5}$$

This simply says that the sum of the proportional changes in vehicle price, fuel efficiency, and the user cost of capital must equal the proportional change in gasoline prices. But if $c = 0.365$, then $dP/P = 0.365(dE/E)$. Thus, if $dr/r$ is zero,

$$dp_g/p_g = 1.365\ (dE/E). \tag{6}$$

Since the real price of gasoline rose by 40 percent from 1970 through mid-1983, vehicle manufacturers might have been expected to increase

fuel economy (for given other attributes) by about 29 percent. Since the annual capital charge has also risen slightly, the expected increase is even smaller. The sum of interest plus depreciation has risen by about 1 percentage point, from 37 percent to 38 percent of the initial car price. Thus $dr/r$ is approximately 0.03. This suggests that manufacturers should have increased fuel efficiency by about 26 percent from 1970 through 1983.

Our estimates in tables 6-5 and 6-6 are surprisingly close to this prediction. General Motors and Ford appear to have exceeded the 26 percent prediction, but Chrysler has fallen somewhat short of it. Overall, it appears that the improvement in fuel economy for the industry was very close to what would have been expected without the CAFE standards.

### *Sources of Improvement in Fuel Economy*

At this point, we might attempt to summarize the sources of fuel economy improvements realized since the 1973 Arab oil embargo. Manufacturers have reduced engine size and acceleration and downsized their vehicles. In addition, consumers have gravitated toward the smaller size classes. Finally, technology and aerodynamic design have changed, increasing fuel economy for any given weight-displacement combination. How much has each of these changes contributed to improved fuel efficiency?

The improvement has been considerable, if one is to believe EPA mileage estimates. Both city and average (55 percent city/45 percent highway) mileage have nearly doubled from their 1973 lows (table 6-1). These EPA estimates are known to overstate actual fuel economy obtained from road tests such as those conducted by Consumers Union.

The sources of mileage improvement between the 1974 and 1984 model years can be summarized as follows. The average new passenger-car weight fell by approximately 22 percent in this period, from 3,968 pounds to 3,103 pounds. This was due to downsizing and to a shift away from larger cars. The average displacement of engines in U.S. automobiles declined by 38 percent, from 289 cubic inches to 179 cubic inches. Finally, the share of front-wheel-drive passenger cars rose from virtually zero in 1974 to 52 percent in 1984.[15]

The results in table 6-4 suggest that the elasticity of the average city-

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logical changes that result in an increase in the average car price of $1,031. This translates into an estimate of the elasticity of costs with respect to fuel economy of 0.373.

Finally, GM has estimated that during the 1974–81 period it has invested $1 billion for each 0.5 mpg improvement. At a 10 percent cost of capital and a five-year life of this capital, this translates into an elasticity of 0.412 for a 1977 midpoint. William G. Agnew, *Automotive Fuel Economy Improvement*, General Motors Research Laboratories, GM-3493 (Warren, Mich.: GM, 1980).

[15] R. M. Heavenrich and others, "Passenger Car Fuel Economy . . . Trends thru 1984," Environmental Protection Agency Paper 840499 (EPA, 1984).

highway mileage with respect to weight is approximately −0.8, the elasticity with respect to displacement is about −0.13, and the effect of front-wheel drive is to raise mileage by about 5 percent.[16] Using the 1984 weights (and excluding luxury vehicles), this suggests an 18 percent improvement due to weight reductions, a 5 percent increase in fuel efficiency due to smaller engines, and a 3-percent improvement due to the shift to front-wheel-drive cars. Our estimate of other design technology influences between 1974 and 1984 (from table 6-5) is a 21 percent improvement in average mileage. Multiplying these four components together, we get a total improvement of 54 percent, of which design changes and reductions in engine size and weight are each approximately equally responsible. This is substantially less than the 87 percent improvement in the EPA's estimates,[17] but the divergence of EPA estimates, obtained from test cars operated on a dynamometer, and actual road performance is widely recognized.

### *Pricing to Induce Small Car Purchase*

It is possible that the CAFE standards have had another impact—on the relative prices of large and small cars.[18] While the standards may not have affected the pace of fuel efficiency improvement for cars in each size class, they may have forced the vehicle producers to raise large car prices relative to the price of smaller, more fuel-efficient ones in order to meet year-to-year CAFE requirements.

To analyze the 1978–84 pricing decisions by the domestic producers, we estimate a hedonic list-price equation for comparably equipped cars over the 1970–77 period to predict 1978–84 prices. The hedonic equation estimated includes variables for vehicle weight (*WEIGHT*), acceleration from 0 to 60 mph (*ACCEL*), the real cost per mile of gasoline consumption for a 55 percent-45 percent mix of city and highway driving (*GASCOST*), indexes of the quality of ride (*RIDE*) and handling (*HAND*), a set of dummy variables for size class (*COMPACT*, *INTERMEDIATE*, *FULLSIZE*, and *LUXURY*), and dummy variables for model years. The sample is all cars tested by Consumers Union (112 between 1970 and 1977) for which complete data are available. *ACCEL*, *GASCOST*, *RIDE*, and *HAND* are based upon Consumers Union test results.

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[16] The results in tables 6-4 and 6-6 diverge on displacement and front-wheel drive. This calculation is for illustrative purposes, but its uncertain nature should be noted.

[17] Heavenrich and others, "Passenger Car Fuel Economy," p. 4.

[18] See John E. Kwoka, Jr., "Behavior of an Auto Firm under the Fuel Economy Constraint," Bureau of Economics Working Paper 28 (Federal Trade Commission, 1980).

**Table 6-7. Estimates of Equation Used to Predict 1978–84 Model Year Prices[a]**

| *Independent variable* | *Estimate* | *Independent variable* | *Estimate* |
|---|---|---|---|
| Constant | 7.028 | *FULLSIZE* | 0.149 |
| | (64.47) | | (2.58) |
| *WEIGHT* | 0.00016 | *LUXURY* | 1.092 |
| | (3.90) | | (11.72) |
| *ACCEL* | 0.0022 | *D71* | −0.041 |
| | (0.51) | | (1.30) |
| *GASCOST* | −0.961 | *D72* | −0.028 |
| | (0.61) | | (0.78) |
| *RIDE* | 0.064 | *D73* | −0.066 |
| | (2.78) | | (2.19) |
| *HAND* | 0.008 | *D74* | −0.155 |
| | (0.52) | | (3.98) |
| *COMPACT* | 0.053 | *D75* | −0.106 |
| | (1.75) | | (2.56) |
| *INTERMEDIATE* | 0.109 | *D76* | −0.121 |
| | (2.50) | | (3.34) |
| | | *D77* | −0.067 |
| *Summary statistic* | | | (1.78) |
| $\bar{R}^2$ | 0.899 | | |

a. Dependent variable is logarithm of the list price deflated by the consumer price index. Numbers in parentheses are *t*-statistics.

The results of the hedonic estimation are reproduced in table 6-7 for small (compact and subcompact) and large (intermediate and full-size) cars. When the estimated equation is used to project 1978–84 model prices, deflated for changes in the consumer price index, it generally underpredicts actual prices. In part, this is because regulatory costs are not netted out of our new car price series, but it also reflects the sharp increase in new car prices after 1980, probably because of the Japanese import restraints.

It is difficult to see any effect upon relative prices of the CAFE standards through 1981. The table below shows the average prediction error as a share of the forecast values for the 1978–84 model years. In 1979 GM and Ford were very close to their CAFE minimum, but there does not seem to be any noticeable difference between small- and large-car prediction errors in that year. For the next two years, the soaring price of gasoline alleviated the CAFE pressure while greatly exacerbating the industry's problems with Japanese imports. From 1982 through 1984, the prediction errors rise substantially, partly in response to increased emissions control costs, but also because of the Japanese import quotas. By 1984, it is clear that the large car residual is substantially larger than the prediction error for smaller cars. This is quite consistent with the fact that Ford and GM fell substantially short of the CAFE requirement in 1982–84 as gasoline prices fell. By 1984, it appears that this deficiency led to substantial upward pressure on large car prices.

| | *1978* | *1979* | *1980* | *1981* | *1982* | *1983* | *1984* |
|---|---|---|---|---|---|---|---|
| Small cars | −0.020 | −0.055 | −0.006 | 0.110 | 0.125 | 0.154 | 0.117 |
| Large cars | −0.003 | −0.029 | −0.112 | 0.004 | 0.197 | 0.117 | 0.235 |

## The Gas Guzzler Tax

The gas guzzler tax, imposed in 1980, is designed to penalize manufacturers for producing individual model lines that fall below a given mileage (city/highway) in each model year. As the table below shows, this standard rises to 22.5 mpg for the 1986 model year, and the tax can become quite severe.[19] For example, manufacturers will have to pay $1,050 per car for any automobile achieving only 19 mpg, and a staggering $3,850 for a 12 mpg car. By fiscal 1983 these manufacturers' excise taxes had generated only $4 million a year in revenues,[20] but they could become much larger in a world of falling gasoline prices.

| *Mileage (miles per gallon)* | *Tax (dollars)* |
|---|---|
| 22.5 or more | 0 |
| 21.5–22.5 | 500 |
| 20.5–21.5 | 650 |
| 19.5–20.5 | 850 |
| 18.5–19.5 | 1,050 |
| 17.5–18.5 | 1,300 |
| 16.5–17.5 | 1,500 |
| 15.5–16.5 | 1,850 |
| 14.5–15.5 | 2,250 |
| 13.5–14.5 | 2,700 |
| 12.5–13.5 | 3,200 |
| Less than 12.5 | 3,850 |

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[19] 26 U.S.C. 4064.

[20] Internal Revenue Service, *News Release*, IR-84-38, March 6, 1984.

## Conclusions

This chapter has reviewed in some detail the progress that the three major U.S. automobile producers have made in improving fuel economy since 1970. The results show that General Motors started earliest and achieved the greatest improvement in fuel efficiency for a given weight and engine size, followed by Ford and Chrysler, in that order. Chrysler began with the most fuel-efficient cars for a given weight and displacement, but Ford and GM succeeded in achieving the greatest improvement through design changes and technological advances in drive trains. Nevertheless, Chrysler emerged in 1985 as the only company without a CAFE problem because it had virtually abandoned the larger-car market. The Department of Transportation's 1985 decision to reduce the CAFE standard for 1986 cars to 26.0 mpg may alleviate much of the pressure on GM and Ford.

The principal conclusion of this chapter is that the automobile producers' increase in fuel economy is about what one should have expected given the rise in gasoline prices since 1973. The CAFE standards appear to have provided little but nuisance value until recently. As gasoline prices have fallen in real terms, the standards have become a binding constraint upon producers attempting to satisfy the demand for larger cars. They have also made it very difficult for Ford and GM to produce or purchase their smaller cars in Japan or Korea, where production costs are much lower at the 1984–85 value of the dollar. Thus CAFE has become an issue of trade protection as much as one of energy conservation.[21]

Should the CAFE program be continued? At present, there seems to be little reason for suggesting that automobile drivers should not be allowed to respond to market prices of energy in the same fashion as commercial, industrial, or residential users of fossil fuels. If there is a societal case for increasing conservation efforts—and it appears rather weak in 1985—the appropriate mechanism would appear to be a federal tax on all liquid and gaseous hydrocarbons, not a set of technological standards applied to new cars.[22] The CAFE standards only encourage higher large car prices and the postponement of replacement decisions. This postponement is counterproductive with respect to the policy of reducing emissions, vehicle deaths, and fuel consumption. Since the Japanese import restraints were lifted in March 1985, the CAFE standards have become an even greater problem for Ford and GM because the Japanese imports will take small car sales away from these companies, leaving them with an even greater CAFE deficiency. In 1985 there were suggestions that a decision to eliminate Japanese export quotas could be combined with the elimination of CAFE standards.

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[21] This point is made by David R. Henderson in "The Economics of Fuel Economy Standards," *Regulation*, vol. 9 (January–February 1985), p. 46.

[22] See Blair and others, "The Impact of Improved Mileage on Gasoline Consumption," for an estimate of the effectiveness of regulatory and gasoline-price options for reducing gasoline consumption.

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